LATE PALEOZOIC SPONGE FAUNAS OF THE TEXAS REGION

THE SILICEOUS SPONGES

ROBERT M. FINKS

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THE SILICEOUS SPONGES

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INTRODUCTION

ABSTRACT

THE PRESENT PAPER is a taxonomic and faunal study of the siliceous sponges of the later Pennsylvanian and Permian of the mid-continent region, including the standard Permian section of west Texas. It is based primarily on large collections at the United States National Museum and at the American Museum of Natural History, as well as on the type specimens of all previously described species from the same area. A general introductory discussion reviews the composition and historical development of the entire sponge faunas of the area and geologic systems studied, including the calcareous sponges which are not treated taxonomically here.

The sponge faunas discussed here are the most diverse known in the geologic record between the Devonian and the Jurassic. The siliceous sponges dealt with in the present paper constitute about half of the total sponge fauna in terms of numbers of species. Forty-three named species are described, plus nine new but unnamed forms. Three new superfamilies, seven new families, 17 new genera, and 32 new species have been established. The anatomy of *Heliospongia* has been reinterpreted on the basis of excellently preserved material, and it has been placed among the monactinellid demosponges. The evolution of the hexactinellids has been reconsidered, and it is concluded that in the early Paleozoic two main lines diverged from a common stock, one of which gave rise to many later dictyonines.

In the descriptions of individual species, particular attention has been paid to individual variation, to ontogenetic development, and to evidences for ecological relationships exhibited by the specimens. The large size of the collections and the generally excellent preservation of the material have made such aspects of the study feasible. Only those species represented by nearly complete specimens have been named, for isolated spicules or small fragments of sponges provide insufficient morphological information.

Faunal facies can be recognized, which are related to bathymetry inferred from physical stratigraphic evidence. These are similar in distribution to present communities of sponges. The shoal-water faunas were dominated by calcareous sponges and the deeper-water faunas by siliceous sponges. Evidence is presented that the marginal areas of the stagnant-basin facies of the Texas Permian were not completely anaerobic, despite the high organic content of the sediment, because the sponges and some of the associated faunal elements were autochthonous to the sediments. The late Paleozoic shoal-water sponge fauna in the Texas region shows a continuous and partly endemic development. A significant external faunal element appears at the beginning of the Leonardian. Stratigraphic zonation of the sponges tends to confirm that established on the basis of the other faunal elements.

The taxonomic composition of the Permian sponge faunas, in relation to earlier and later faunas, indicates that the Paleozoic-Mesozoic boundary is marked by the extinction of several long-ranging Paleozoic families that flourished until the end of the Permian. The dominant groups of Mesozoic sponges, on the other hand, were already present in the late Paleozoic and seem not to have been affected by the post-Permian withdrawal of epicontinental seas.

MATERIAL

The upper Pennsylvanian sediments of the mid-continent region, and the thick Permian section of west Texas, contain an unusual abundance of fossil sponges at many localities. The pioneering studies of Girty (1908, 1909, 1915) first revealed the diversity of these sponge faunas, which even at that time were the most extensive known from the upper Paleozoic. Later work by Ralph H. King (1933, 1938, 1943) added further to our knowledge of these forms. In the last two decades an extensive collecting program has been undertaken in the west Texas Permian area by G. Arthur Cooper and his associates at the United States National Museum, and by Norman D. Newell and his associates at the American Museum of Natural History. Preparation of this material, much of which is silicified and has been freed from the limestone matrix with acid, has yielded a splendid suite of well-preserved specimens of fossil sponges. In addition, extensive unstudied collections of sponges from the Pennsylvanian of the mid-continent region, made by Cooper and by Alfred R. Loeblich, Jr., were available at the United States National Museum.

The present paper is based primarily on a study of these collections. It includes a complete taxonomic treatment of the siliceous sponges in these faunas, as well as a general summary of the entire sponge faunas of these beds and their development through time. The taxonomy and evolutionary history of the calcareous sponges, which constitute about half of the fauna, will be treated in a separate paper.

In addition to the collections cited above, the following unstudied material has also been examined: (1) the fossil sponges from these beds in the collections of the United States Geological Survey, including a large collection from the Permian of the Sierra Diablo, in west Texas, made by P. B. King and J. B. Knight; (2) a large collection at Princeton University, made by S. J. Kříz from the Sierra Diablo; and (3) a series of collections at Yale University made by R. E. King from the Permian of west Texas and from the Permian of southern Coahuila, Mexico. The type specimens of all previously described species have also been studied, as well as the type lots of Girty's species in the collections of the United States Geological Survey. Type and topotype material of early Paleozoic sponges, in the collections of the United States National Museum, were also examined in connection with the revision of certain families.

ACKNOWLEDGMENTS

Professor Norman D. Newell, of Columbia University and the American Museum of Natural History, suggested this study for a doctoral dissertation and with Prof. John Imbrie of Columbia University supervised its prosecution. Professor Newell made available the collections and facilities of the American Museum of Natural History and urged the inclusion in this study of the splendid collection of fossil sponges at the United States National Museum, as well as material at Yale University. Dr. G. Arthur Cooper, of the United States National Museum, gave much aid and encouragement and made available the collections and facilities in his charge. Dr. J. Brookes Knight, formerly of the United States National Museum, urged the inclusion of material in the collections of Princeton University and arranged for the writer to study them. Prof. Benjamin F. Howell, of Princeton University, and Prof. Carl O. Dunbar, of Yale University, made available collections of sponges at their respective institutions. The late Dr. James Steele Williams, of the United States Geological Survey, made available collections in his charge. Other material was lent by Dr. Donald W. Boyd, of the University of Wyoming, Dr. Preston E. Cloud, Jr., of the United States Geological Survey, and Dr. John T. Lonsdale, of the Texas Bureau of Economic Geology. The continued cooperation of the following greatly facilitated the prosecution of this study in many ways: Mr. James Benn, Dr. Richard B. Boardman, the late Dr. William F. Foshag, Dr. E. P. Henderson, Miss Muriel Joseph, Dr. Alfred R. Loeblich, Jr., Dr. David Nicol, and Dr. George Switzer, all of the United States National Museum; Miss Marjorie Arnold, Dr. Raymond O. Douglass, Jr., Dr. Helen Duncan, Mr. Lloyd G. Henbest, Mr. Harold Saunders, and Dr. Ellis L. Yochelson, all of the United States Geological Survey; and Dr. Roger L. Batten of the University of Wisconsin. Mr. Louis J. Fracchiolla drafted the charts. All photographs and drawings are by the writer, unless otherwise indicated.

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LIST OF ABBREVIATIONS

The following abbreviations of names of institutions and collections have been used throughout this paper in citing locality and catalogue numbers. The catalogue numbers may be identified by the letters "No." preceding them.

A.M.N.H., the American Museum of Natural History

B.E.G., Texas Bureau of Economic Geology
D.W.B., field locality numbers of Dr. Donald W. Boyd, University of Wyoming
K.U., University of Kansas
P.U., Princeton University
U.S.G.S., United States Geological Survey
U.S.N.M., United States National Museum
Y.P.M., Yale University, Peabody Museum of Natural History

LATE PALEOZOIC SPONGE FAUNAS

The late Paleozoic sponge faunas of the mid-continent region of the United States, and particularly those of the west Texas Permian, are unique in containing many species of all three classes of the phylum. They display a comprehensive cross section of late Paleozoic sponge life unparalleled by any known fauna from other parts of the world, and include the only known Permian examples of the Class Hexactinellida. Undoubtedly the diversity of these faunas stems from the many locally contrasting environments that were developed in the comparatively small area of the west Texas region because of the particular tectonic conditions there. Reef, shelf, and deeper-water environments were coexistent in proximity to one another, each one populated by rich sponge associations. The shoal-water areas (reef and shelf) were inhabited by a fauna dominated by calcareous sponges, while the deeper-water areas supported a contemporaneous fauna dominated by siliceous sponges. Some of the siliceous sponges were common to both environments.

The sponge faunas known from upper Paleozoic deposits elsewhere in the world appear to represent but one or the other of these two contrasting associations. The Permian faunas described from Spain (Steinmann, 1882), Sicily (Di Gregorio, 1930; Parona, 1933), Tunisia (Termier and Termier, 1955), India (Waagen and Wentzel, 1887), Indo-China (Mansuy, 1913, 1914), and Japan (Hayasaka, 1923; Yabe and Sugiyama, 1934) correspond to the shoal-water calcareous sponge fauna of the Texas area. The peculiar silicisponge fauna of Timor (Gerth, 1927) appears to represent a deeper-water facies. The scattered faunas reported from Spitzbergen (Dunikowski, 1884; Hinde, 1888b), Russia (Stuckenberg, 1895; Tschernyschew, 1898; Tschernyschew and Stepanov, 1916), and Ellesmere Land (Tschernyschew and Stepanov, 1916) contain only silicisponges, but of types that in the Texas area occur in both deep and shallow water. The absence of calcisponges from the latter group of localities suggests that the waters were not shallow enough, or warm enough, to support a flourishing calcisponge fauna. The confinement of the rich thalamid calcisponge faunas of the Permian to relatively low-latitude localities is suggestive of a temperature control of their distribution (see Stehli, 1957).

The present fauna fills an important gap in our knowledge of the history of sponges, for it is the most complete available between the Devonian and the Jurassic. Occurring, as it does, close to the Paleozoic-Mesozoic boundary, it also sheds an important light on the nature of this major faunal break. It reveals quite clerarly that the break involves the extinction of archaic groups which had dominated the Paleozoic sponge faunas until the very end. The forms that were to dominate the succeeding Mesozoic era had already become well established in the later Paleozoic. Of the 48 genera of calcisponges and silicisponges in the present fauna, 25, or more than half, belong to families that did not survive the Paleozoic. Out of this group, 13 of the genera belong to families that were important elements of the pre-Carboniferous sponge faunas, six are related to such groups, and the other six are related to groups present in the Mesozoic. The remaining 23 genera of the fauna all belong to families that survived into the Mesozoic and were an important element of the later faunas. These data are analyzed in the following table:

PENNSYLVANIAN AND PERMIAN FAMILIES	GENERA PRESENT
Extinct at end of Paleozoic	
Originated before Carboniferous	
Demospongea	
Anthaspidellidae	2
Chiastoclonellidae	3
Hindiidae	1
Hexactinellida	
Dictyospongiidae	4
Teganiidae	2

Calcarea	
Asteractinellidae	1
Originated in later Paleozoic	
Related to pre-Carboniferous groups	
Demospongea	
Anthracosyconidae	3
Hexactinellida	
Stereodictyidae	1
Stiodermatidae	1
Stromatidiidae	1
Related to post-Carboniferous groups	
Demospongea	
Heliospongiidae	3
Haplistiidae	2
Hexactinellida	
Pileolitidae	1
Survived into Mesozoic	
Originated before Carboniferous	0
Originated in later Paleozoic	
Related to pre-Carboniferous groups	
Hexactinellida	
Docodermatidae	3
Related to post-Carboniferous groups	
Demospongea	
Jereidae	1
Calcarea	
Pharetronida (one family)	4
Thalamida (five families)	15

One of the striking features of the Permian fauna is the abundance of archaic groups, such as the Anthaspidellidae, Chiastoclonellidae, and Dictyospongiidae, not only in terms of genera, but also in terms of individuals. Another surprising circumstance is the numerical abundance of pharetronid calcisponges, which constitute a large proportion of the Mesozoic faunas and which appear here for the first time. A major element of the late Paleozoic fauna, however, consists of forms that first became abundant in late Paleozoic times and continued into the Mesozoic. These are the thalamid calcisponges and the brachiospongioid hexactinellids. The latter group was essentially an archaic Paleozoic one, but it shows its greatest diversity in the Permian, and isolated spicules from as high as the Jurassic may record its continuance into the Mesozoic. The former group originated in the Carboniferous and reached the peak of its abundance in Permian and Triassic times, ultimately becoming extinct at the end of the Cretaceous. This group is the dominant element in the sponge reefs of the Permian and is an important, if not dominant, element in patch reefs of the Alpine Triassic (see Sieber, 1937).

It has been suggested that the mass extinctions of marine invertebrates at the end of the Paleozoic were occasioned by the retreat and temporary disappearance of the epicontinental seas at this time. The restriction of these seas is well documented from geologic evidence. The sponges, however, seem not to have been much affected by such spatial restrictions. The calcareous sponges, which apparently were confined to shallow-water environments in the Permian and probably were so in the Triassic, exhibit no diminution in variety across the Paleozoic-Mesozoic boundary. On the other hand, many siliceous sponge families, which inhabited deeper-water areas during the Permian, did become extinct at the end of the Paleozoic. It would seem, therefore, that conditions other than mere restriction of space were responsible for the extinctions among the sponges.

EVOLUTION IN THE PALEOZOIC SILICEOUS SPONGES

The siliceous sponge fauna treated in the present study represents the culmination of many diverse lines of development from earlier Paleozoic forms. The data presently available are scarcely sufficient to establish secure phylogenies of all the siliceous sponges, but many suggestive lines of evidence are presented in the monumental work of De Laubenfels (1955), and the present rich collections are helpful in indicating the diversity of types established by the end of the Paleozoic era. Under the headings of the various families and superfamilies in the systematic part of this paper are discussed the possible relationships of the groups. It remains here to summarize certain aspects of this material, much of which, unfortunately, must remain quite conjectural.

The earliest hexactinellid faunas, such as those from the middle Cambrian Burgess shale (Walcott, 1920) and from the middle Ordovician Utica shale (Rauff, 1893, 1894;

and others), consist largely of simple, thin-walled, sac-like forms of the family Protospongiidae. These are surely as close as we can come to an ancestral type of later hexactinellids. These forms show essentially no specialization of spicules, and the simplest examples have a uniform spiculation of stauracts disposed in strictly parallel orientation. Quite a different body plan is shown by the Ordovician sponge *Brachiospongia*. This is a thick-walled form, with a specialized layer of large dermal spicules and a less regular diposition of the interior spicules. The known hexactinellids of the later Paleozoic appear to be descendants of one or the other of these two early Paleozoic types. Both of these lines, curiously enough, share a common evolutionary trend towards the development of increasing rigidity of the skeleton.

The protospongioid line retains the uniform spiculation and parallel orientation of the skeletal elements. In the middle Paleozoic the dominant group in this lineage is the family Dictyospongiidae, in which the stauracts are lengthened and more closely apposed to one another. An inner layer of longitudinal and horizontal bundles of monaxons also makes its appearance in this group, but the sponge remains essentially thin-walled. In the Permian fauna studied here, there are two groups which probably represent divergent lines from this family. In them a stronger skeleton is achieved by the hypertrophy of different parts of the dictyosponge skeletal organization. One group, the Stereodictyidae, develops a thick and rigid body wall by multiplying the horizontal and vertical monaxon bundles of the dictyosponge inner skeleton and eliminating the outer layer of stauracts. This group seems not to have survived the Permian. The other group, represented by the genus *Microstaura*, enlarged the outer layer of parallel stauracts into a regular cubic mesh of hexacts. The spicules in this form still remain separate from one another, though they intimately overlap. It is but a short step from this type of body wall to the continuously fused cubic mesh of the true dictyonine hexactinellids, which are first known from the later Triassic. There is a good possibility that the Dictyida arose from late Paleozoic sponges similar to *Microstaura*.

The brachiospongioid line seems to have taken another path to the attainment of a rigid skeleton. There is a general tendency in those late Paleozoic sponges with body organization similar to that of *Brachiospongia* to enlarge and elaborate the specialized dermal spicules. Two of these species, *Docoderma rigida* and *Stioderma coscinum*, develop, in their adult stages, a heavy and rigid dermal skeleton by the lateral fusion of the dermal spicules. No Mesozoic or later examples of such sponges are known, but the occurrence of isolated large dermalia of brachiospongioid type in the Jurassic of Germany suggests that some survivors of this line may have persisted to this time.[1]

The lithistid demosponges first appear in the Ordovician. At that time two principal stocks were present which have left descendants extending down to Mesozoic and possibly Recent times. These groups are the Tetracladina and the Eutaxicladina. The latter group was highly conservative throughout its long history. In the Ordovician it had already divided into two main subgroups, those similar to *Astylospongia* and those similar to *Hindia*. No evolutionary trends can be seen in the astylospongiids, and the group is absent from the known late Paleozoic faunas. The Mesozoic *Cladodia* and the Cenozoic *Vetulina* may be descendants of this group. The hindiids are present in the later Paleozoic and show a trend during that time towards the reduction of the distal ray on the spicules. This feature persists in the Mesozoic family

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[1] The recent monograph by Reid (1958) came to the writer's attention after the present paper was completed. Many aspects of Reid's important contribution are pertinent to the matters considered herein, but unfortunately they cannot be discussed adequately without an extensive rewriting of this paper. Among other revisions of hexactinellid taxonomy, Reid established a new order, Reticulosa (Reid, 1958, p. xlv), provisionally attached to the Hexasterophora, for Paleozoic sponges here largely included in the superfamily Protospongioidea. Diagnostic features of this new order include the parallel orientation of dermalia so as to produce regular quadrules, as well as the presence of paraclavules (umbels). The Docodermatidae of the present paper might also be regarded as fitting into this group because of the presence of such features in some species. On the other hand, if the large dermalia of the Brachiospongioidea, including the docodermatids, be considered as hypodermalia, and the "supradermal mesh" as autodermalia, then they might be assigned to Reid's new suborder Hypodermaria of the Order Lyssacinosa (*op cit.*, p. xlv).

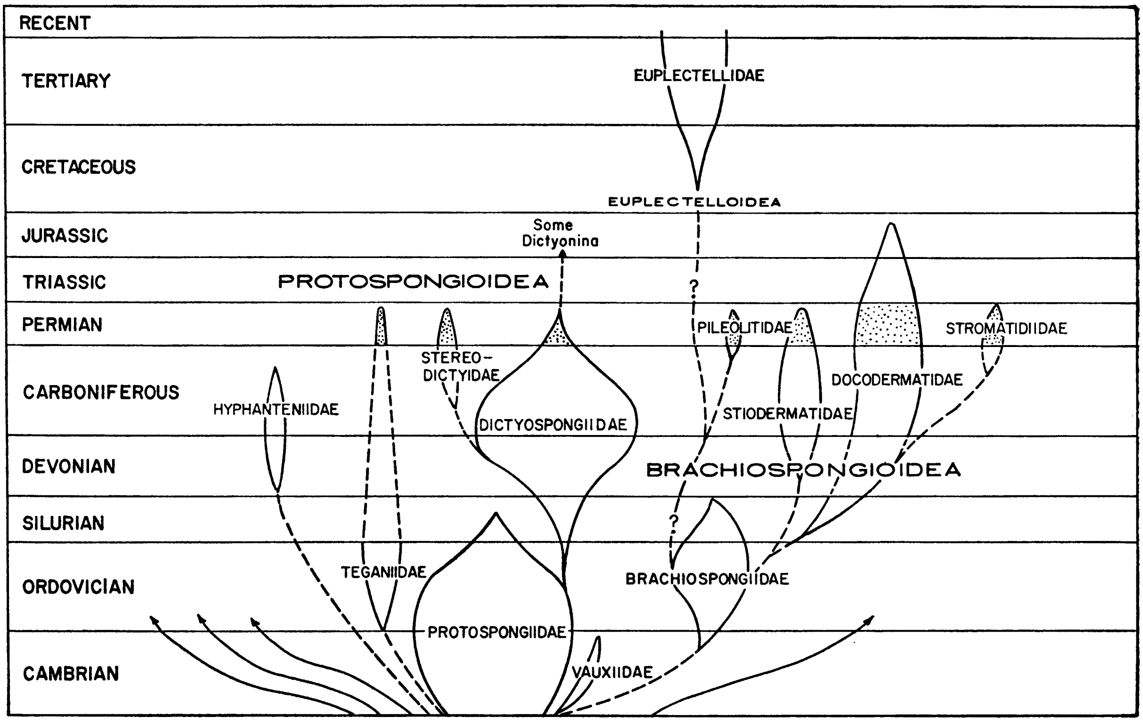

RECENT
TERTIARY
CRETACEOUS
JURASSIC
TRIASSIC
PERMIAN
CARBONIFEROUS
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
EUPLECTELLIDAE
EUPLECTELLOIDEA
Some Dictyonina
PROTOSPONGIOIDEA
?
PILEOLITIDAE
STROMATIDIIDAE
STEREO-DICTYIDAE
DOCODERMATIDAE
HYPHANTENIIDAE
DICTYOSPONGIIDAE
STIODERMATIDAE
BRACHIOSPONGIOIDEA
?
TEGANIIDAE
BRACHIOSPONGIIDAE
PROTOSPONGIIDAE
VAUXIIDAE

FIG. 1. Suggested phylogeny of the principal known groups of Paleozoic Hexactinellida. The vertical scale is roughly proportional to absolute time. The width of the shape representing each family is roughly proportional to its relative taxonomic diversity (number of genera) at a given stratigraphic level.

Gignouxiidae which is probably a descendent group. Subsequent developments involve the assumption of a vasiform shape and the appearance of specialized dermal spicules.

The Tetracladina, throughout their long history, show a persistent trend towards a decreasing regularity of the spicular net, with which is associated a change in the predominant type of principal skeletal spicule. In the Ordovician this group is represented only by the family Anthaspidellidae. The anthaspidellid skeleton is organized into highly regular radial series of horizontally oriented dendroclones. These spicules are very nearly monaxonic, with a smooth shaft bearing terminal arborescences at each end. In the Silurian a less regular grade of organization makes its appearance as the family Chiastoclonellidae. The external form of these sponges is very similar to that of the anthaspidellids, and the basically radial organization of the skeleton is retained. The radial spicule rows, however, are much less strictly organized, and the terminal arborescences of the spicules increase in size relative to the shaft, producing the spicule form called a chiastoclone. Strictly equal-armed tetraclones are also present in these sponges. In the Permian faunas, representatives of the family Chiastoclonellidae have a less strictly radial organization of the spicules than that shown by the Silurian forms, and they possess more numerous, simple tetraclones. Alongside these forms, as well as alongside some persistent anthaspidellids, there appear the first examples of the more modern tetracladines, in the form of *Jereina*, in which the spiculation consists of tetraclones without any arrangement in radial rows. This type of structure is dominant in the Mesozoic tetracladines.

Another family of tetracladines, also present in the Permian fauna, has a highly regular skeletal net but one of a totally different organization. This is the family Anthracosyconidae, in which dendroclone-like spicules are arranged in concentric layers, with the spicule shafts oriented radially rather than horizontally. The origin of this group is obscure, for it has no previous fossil record, but it must represent a separate line of development from early tetracladine types. In some species of this group the spicules tend to be collected into bundles, and the shafts develop lateral connecting processes. The spicules thereby come to resemble somewhat those of the rhizomorine lithistids. This is probably a convergent development.

True Rhizomorina are also present in the late Paleozoic. The most primitive known type is represented by *Haplistion* of the Carboniferous and Permian, in which the body plan is regularly radial and the rhizoclone spicules are organized into uniform bundles, or fibers. The subsequent development of this group in the Mesozoic involves trends towards increasing diffuseness of the spicule fibers and loss of the radial organization, as well as the development of specialized dermal spicules and of differentiated incurrent and excurrent surfaces. The beginnings of these later developments are already present in the Pennsylvanian species *Chaunactis foliata.*

A suggested phylogeny of the Paleozoic hexactinellids discussed in this paper is presented in figure 1. A similar phylogenetic diagram for the lithistid demosponges is given in figure 2.

STRATIGRAPHY

The stratigraphy of the west Texas Permian has been described extensively in the works of Philip B. King (1931, 1934, 1942, 1948). The more recent monograph of Newell and others (1953) has analyzed the detailed stratigraphy of the Guadalupe Mountains area with special reference to its paleoecological implications. This last work, in particular, has served as the basis for the discussions of facies presented in the present paper. The

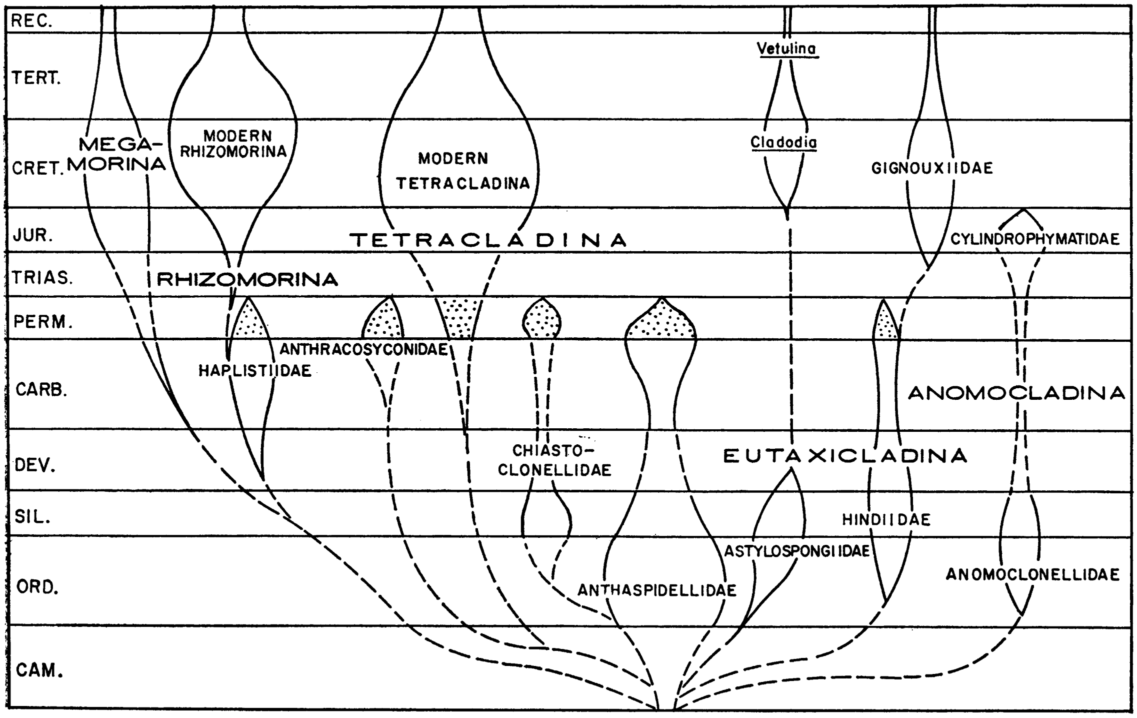

REC.
TERT.
CRET.
JUR.
TRIAS.
PERM.
CARB.
DEV.
SIL.
ORD.
CAM.
Vetulina
Cladodia
MEGA-MORINA
MODERN RHIZOMORINA
MODERN TETRACLADINA
GIGNOUXIIDAE
TETRACLADINA
CYLINDROPHYMATIDAE
RHIZOMORINA
ANTHRACOSYCONIDAE
HAPLISTIIDAE
ANOMOCLADINA
CHIASTO-CLONELLIDAE
EUTAXICLADINA
HINDIIDAE
ASTYLOSPONGIIDAE
ANOMOCLONELLIDAE
ANTHASPIDELLIDAE

FIG. 2. Suggested phylogeny of the Order Lithistida, Class Demospongea. The vertical scale is roughly proportional to absolute time. The width of the shape representing each taxonomic group is roughly proportional to its relative taxonomic diversity (number of genera) at a given stratigraphic level.

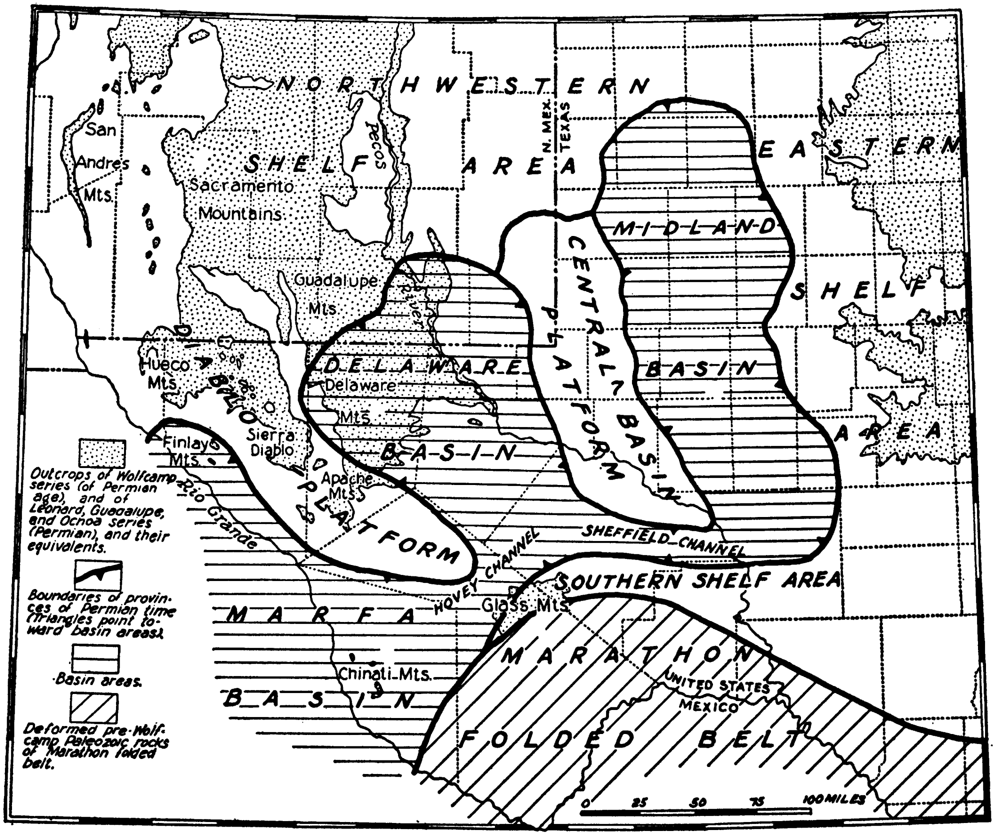

NORTHWESTERN SHELF AREA
EASTERN SHELF AREA
MIDLAND BASIN
CENTRAL BASIN PLATFORM
DELAWARE BASIN
DIABLO PLATFORM
SHEFFIELD CHANNEL
HOVEY CHANNEL
SOUTHERN SHELF AREA
MARFA BASIN
MARATHON FOLDED BELT
San Andres Mts.
Sacramento Mountains
Pecos
Guadalupe Mts
Hueco Mts.
Delaware Mts.
Sierra Diablo
Finlay Mts.
Apache Mts.
Rio Grande
Glass Mts.
Chinati Mts.
N. MEX.
TEXAS
UNITED STATES
MEXICO
0 25 50 75 100 MILES
Outcrops of Wolfcamp series (of Permian age), and of Leonard, Guadalupe, and Ochoa series (Permian), and their equivalents.
Boundaries of provinces of Permian time (Triangles point toward basin areas).
Basin areas.
Deformed pre-Wolfcamp Paleozoic rocks of Marathon folded belt.

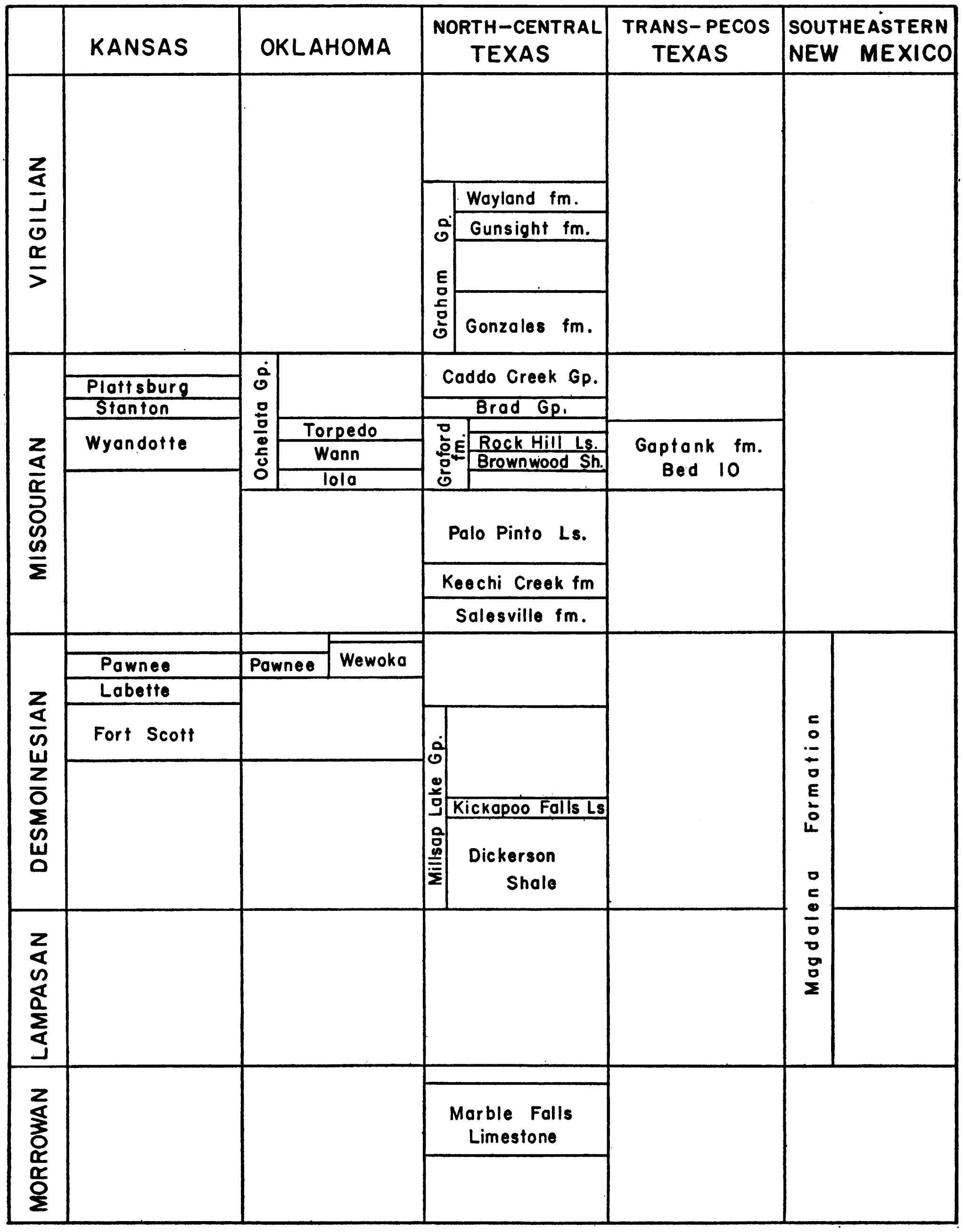
FIG. 3. Permian tectonic and geographic features in the west Texas region. After P. B. King, 1934.

stratigraphy of the lower Leonardian in the Sierra Diablo has been analyzed most recently by Stehli (1954), and a summary of the general stratigraphy of the west Texas Permian is available in Batten (1958). The reader is referred to these works for the general stratigraphic setting of the sponge collections treated here. Because this is essentially a taxonomic and faunal study, no further attempt is made to describe the stratigraphy, but specific aspects of correlation, faunal zones, and lithofacies are discussed under the section on Stratigraphic Zones and that on Faunal Facies. An index map of Permian paleogeography is given in figure 3. Correlation charts of the Pennsylvanian and Permian formations, from which the present material has been obtained, are given in figures 4 and 5.

STRATIGRAPHIC ZONES

The late Paleozoic sponge faunas of the mid-continent region fall rather readily into four broad faunal zones. These are, in ascending order: (1) Desmoinesian to Virgilian, (2) Wolfcampian, (3) Leonardian, and (4) Guadalupian. Each of these zones is characterized by certain genera or species which are confined to them. Also their upper or lower boundaries are marked by the first or last occurrences of longer-ranging forms. Only those forms for which the stratigraphic ranges are relatively well determined from numerous occurrences are included in the present discussion. Other genera and species seem to have restricted ranges but are known from too few localities for definite conclusions as to their stratigraphic usefulness to be drawn.

The first zone coincides with the strati-



	KANSAS	OKLAHOMA	NORTH-CENTRAL TEXAS	TRANS-PECOS TEXAS	SOUTHEASTERN NEW MEXICO
VIRGILIAN			Graham Gp.: Wayland fm. Gunsight fm. Gonzales fm.		
MISSOURIAN	Plattsburg Stanton Wyandotte	Ochelata Gp.: Torpedo Wann Iola	Caddo Creek Gp. Brad Gp. Graford fm.: Rock Hill Ls. Brownwood Sh. Palo Pinto Ls. Keechi Creek fm Salesville fm.	Gaptank fm. Bed 10	
DESMOINESIAN	Pawnee Labette Fort Scott	Pawnee Wewoka	Millsap Lake Gp.: Kickapoo Falls Ls Dickerson Shale		Magdalena Formation
LAMPASAN					
MORROWAN			Marble Falls Limestone		

FIG. 4. Correlation of the Pennsylvanian formations from which sponges described in the present paper were obtained. Adapted from Moore, 1944.

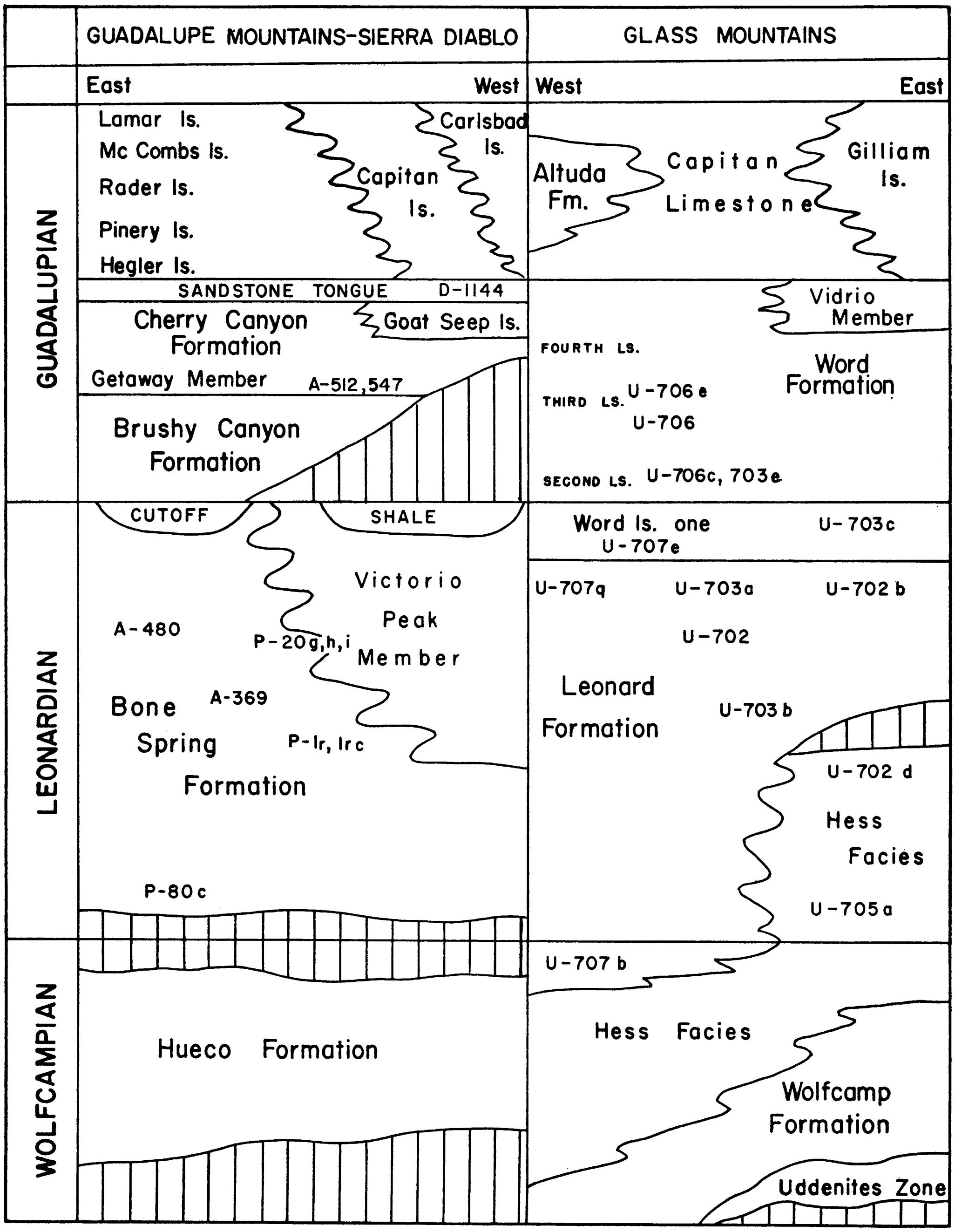

GUADALUPE MOUNTAINS-SIERRA DIABLO
GLASS MOUNTAINS
East
West
West
East
GUADALUPIAN
LEONARDIAN
WOLFCAMPIAN
Lamar ls.
Mc Combs ls.
Rader ls.
Pinery ls.
Hegler ls.
Capitan ls.
Carlsbad ls.
SANDSTONE TONGUE D-1144
Cherry Canyon Formation
Goat Seep ls.
Getaway Member A-512,547
Brushy Canyon Formation
Altuda Fm.
Capitan Limestone
Gilliam ls.
Vidrio Member
FOURTH LS.
THIRD LS. U-706e
U-706
SECOND LS. U-706c, 703e
Word Formation
CUTOFF
SHALE
Victorio Peak Member
A-480
P-20g,h,i
Bone Spring Formation
A-369
P-Ir, Irc
P-80c
Word ls. one U-707e
U-703c
U-707q
U-703a
U-702b
U-702
Leonard Formation
U-703b
U-702d
Hess Facies
U-705a
U-707b
Hueco Formation
Hess Facies
Wolfcamp Formation
Uddenites Zone

FIG. 5. Correlation of the Permian formations of west Texas. Modified after Batten (1958, fig. 1). The positions of some of the important sponge-bearing localities are indicated. *Abbreviations:* A, the American Museum of Natural History; D, Donald W. Boyd collection; P, Princeton University; U, United States National Museum.

graphic ranges of the calcisponge *Maeandrostia* and the demosponge *Coelocladia*. Within this zone the lower and middle Missourian is characterized by the presence of *Heliospongia excavata*, and the base of the Virgilian is marked by the first appearance of "*Amblysiphonella*" ("*A.*" *prosseri*).[1] The genus *Girtycoelia* appears to be confined to the interval from the middle Missourian through the Virgilian. The long-ranging genus *Girtyocoelia* first appears in the middle Missourian.

The Wolfcampian zone has a distinctive sponge fauna and rather well-marked boundaries. The zone can be characterized by the presence of *Coelocladiella philoconcha*, *Haplistion megalochetus*, and two new species of "*Amblysiphonella*" (*Stylopegma*). The most widespread, abundant, and easily recognized sponge fossil of this zone is the hexactinellid *Stereodictyum*. Unfortunately sporadic occurrences of this form are known from Leonardian beds, so that it cannot be cited as an absolute guide to the Wolfcampian, but the presence of numerous specimens at an outcrop is suggestive of a Wolfcampian age. The base of the Wolfcampian is marked by the first appearance of both *Stereodictyum* and *Heliospongia vokesi*. Its upper limit coincides with the disappearance of *Wewokella* ("*Talpaspongia*").

The base of the Leonardian is marked by the first appearances of *Guadalupia*, *Virgola*, and pharetronid genera A and B. Its top coincides with the disappearance of *Fissispongia*. The zone as a whole coincides with the ranges of a new genus related to "*Amblysiphonella*" and of a new species of *Guadalupia*, both of which are quite abundant and widespread in the shelf and patch-reef facies. A great many silicisponge genera appear to be restricted to the Leonardian rocks. Most of these, however, are basin-facies types, and the small number of collections from this facies in the lower and higher beds makes it inadvisable to draw conclusions as to their stratigraphic ranges. The presence of abundant specimens at a particular locality, of the widely distributed shelf-facies genera *Defordia* or *Actinocoelia* may be taken as suggestive of Leonardian age, but the criterion must be used with caution, for a single occurrence of each is known from lower and higher beds, respectively. There are consistent changes in the taxonomic composition of the sponge faunas as one goes from lower to higher beds in the Leonardian series. The data available at present, however, are insufficient for the establishment of well-defined zones.

The base of the Guadalupian is marked by the first appearances of *Cystothalamia nodulifera*, *Guadalupia cylindrica*, and a new species of *Guadalupia*. The whole zone is characterized by the presence of the genus *Cystothalamia*. Certain divisions within this series are characterized by particular calcisponge species, but, as the taxonomy of the Calcarea is not treated in the present paper, a discussion of these subzones cannot be attempted here. The presently known silicisponges are too sporadic in their occurrence to be used as reliable guides, although two genera, *Multistella* and *Stromatidium*, are confined to Guadalupian localities in the present collections.

The upper and lower stratigraphic boundaries of the Wolfcampian and Leonardian faunal zones in the Glass Mountains area have become the subject of controversy in recent years. These problems involve the ages of the "*Uddenites*-zone" of the Gaptank formation, of the first limestone tongue of the Leonard formation, and of the first limestone tongue of the Word formation.

The "*Uddenites*-zone," originally considered by P. B. King (1931) to be part of the Pennsylvanian Gaptank formation, has been considered by Cooper (1953, and personal communication) to be an integral part of Wolfcamp sedimentation and to rest disconformably on the lower part of the Gaptank. The general fauna of the *Uddenites* beds has a distinctly Pennsylvanian aspect, but this is also true of the overlying Wolfcamp shales. Yochelson (1954, p. 233) reported the gastropod *Omphalotrochus* from these beds, a genus previously considered to be confined to the Permian. The testimony of the sponge fauna of the "*Uddenites*-zone" (obtained from U.S.N.M. 701p, 705v; U.S.G.S. 7047) is somewhat equivocal. Three of the species present are known from undoubted Pennsylvanian rocks and also from the shaly beds of the Wolfcamp formation proper. These are *Wewokella solida*, "*Amblysiphonella*" *prosseri*, and *Heliospongia* cf. *ramosa*. Some poorly preserved specimens of a calcisponge shed no more light on the matter, for they appear to be intermediate forms between the Pennsylvanian genus *Maeandrostia* and a new species of "*Amblysiphonella*" (*Stylopegma*) which is present in the overlying Wolfcamp shales. The remaining member of the sponge fauna is the species *Stereodictyum orthoplectum* which is known only from Permian rocks. As in the case of *Omphalotrochus*, it is difficult to tell from this single occurrence whether it is the range of the fossil or the lower boundary of the Permian that should be extended downward. As there seems to be no break between the "*Uddenites*-zone" and the overlying Wolfcamp, either stratigraphically or faunally, it is perhaps better to regard it as being basal Permian. The absence of the common Pennsylvanian sponge *Coelocladia* is also suggestive of a Permian age.

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[1] The relation of the forms here called "*Amblysiphonella*" to the type species of that genus, described by Steinmann (1882) from the upper Paleozoic of Sebargas, Spain, is not clear. "*Amblysiphonella*" *prosseri* Beede, from the Virgilian and Wolfcampian rocks of the present area, appears to be at least subgenerically distinct from a separate lineage that first appears in the Wolfcamp formation and becomes highly diversified in the later Permian rocks, including within it the Leonardian type species of *Stylopegma* King. Most of the "*Amblysiphonella*" reported from the Permian of other parts of the world, such as the fauna from the Salt Range of India described by Waagen and Wentzel (1887), seem to belong to this latter group. The taxonomy of the calcareous sponges is not included in the present paper, and further discussion of this problem cannot be attempted here.

The fauna of the first limestone member of the Leonard formation has been considered to have Wolfcampian affinities (Batten, 1958, p. 164). The sponge fauna in this case argues in favor of a Leonardian age. The new pharetronid genera A and B which are unknown from the Wolfcamp formation, and which are abundant at nearly every sponge-bearing locality in the Leonard formation, make their first appearance in Leonard limestone number 1 (U.S.N.M. 707b). It is of course possible that these forms were actually present in the Texas region during Wolfcamp times but are unknown elsewhere because of the absence of deposits of suitable facies.

The case of Word limestone number 1 is less equivocal. Batten, Cooper, Knight, Newell, and Yochelson (personal communications), who have studied the fauna of this unit intensively, are agreed that it is virtually identical to that of the underlying Leonard formation. The rich sponge faunules available from several localities in this unit (A.M.N.H. 501, 503; U.S.N.M. 703c, 707e) bear out this conclusion. Nearly all the calcisponge genera and species that are abundant in the Leonard formation and that are absent from Guadalupian rocks make their last appearance in Word limestone number 1. Contrariwise, none of the typical Guadalupian forms is present. Although some Leonardian sponge species are absent at this horizon, in particular, two new forms of "*Amblysiphonella*" (*Stylopegma*), which are common in the underlying Leonard formation, the major faunal break undoubtedly comes at the top of this unit. In the present paper, Word limestone number 1 has been identified as Leonardian in the citation of stratigraphic ranges.

The stratigraphic ranges of the more significant genera and species discussed above are summarized in figure 6.

SPONGE ADAPTATIONS

Sponges are of particular value for paleoecological reconstruction. First, because they are sessile animals, they show many adaptations to the nature of their immediate physical surroundings. Second, because they are organisms with a very low level of body integration, they readily reflect local changes in conditions. Third, it is frequently possible to demonstrate that sponge faunules were buried essentially in place, so that paleoecological inferences may be more secure than those based on smaller and more easily transported organisms. Lastly, sponges often serve as a substrate for other sessile animals. It is sometimes possible to show that both forms were alive at the same time, which provides us with definite evidence as to the composition of the local biocoenosis.

Some of the features that reflect environmental conditions are considered below. Many of these have been used to reconstruct aspects of the environment at particular localities in the discussion of faunal facies elsewhere in this paper. Adaptations shown by

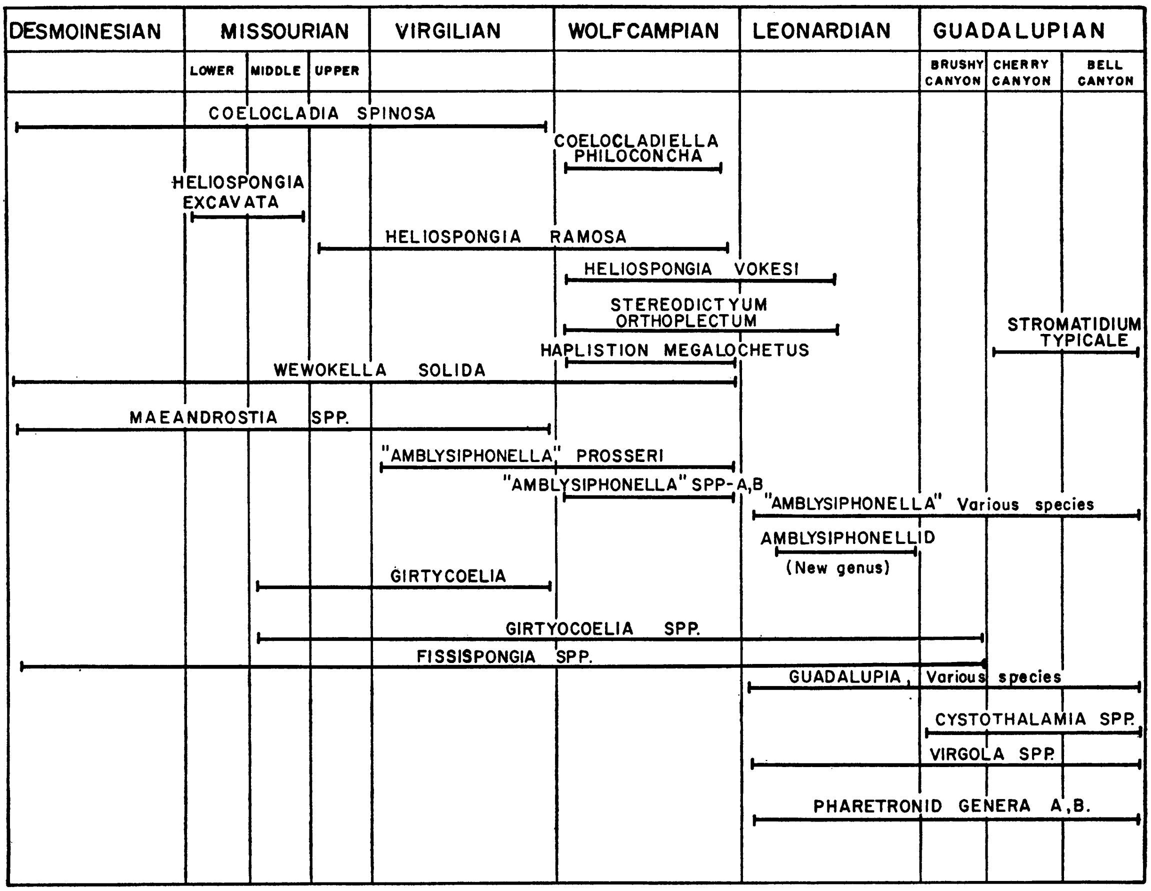

FIG. 6. Stratigraphic ranges of selected genera and species of sponges in the area covered by the present report.

particular species are more fully described under the discussion of that species in the systematic part. The present section attempts to summarize some of these adaptations in a more general way.

BASAL ATTACHMENT

The manner in which the sponge is attached to the substratum can often be demonstrated directly with the individual specimen, which in turn may provide us with data on the nature of the sea floor on which the sponge lived. Many sponges are basally cemented to shells or to other sponges. Where such sponges are numerous at a given locality, such as in many of the Pennsylvanian beds dealt with here, it is hard to avoid the inference that the bottom sediment contained much shell debris. Some sponges of a repent or semi-encrusting habit often incorporate much of the bottom debris into the basal portions of their skeletons. This is true of *Haplistion megalochetus* in Wolfcamp bioherms, and especially of a species of *Virgola* at A.M.N.H. 512. Such sponges give clear evidence of their autochthonous nature, and some specimens of the latter species reveal that the bottom consisted essentially of a closely packed "shell hash." The majority of the calcisponges, heliospongiids, and lithistids of the present collections seem to have attached themselves, at least initially, to shells or other hard objects. One aberrant individual of *Defordia defuncta* at U.S.N.M. 705a completely surrounds a crinoid stem, which passes through it. It appears to have been supported above the sea bottom except at one small point, which implies that the crinoid was rooted in place at this locality.

Another type of adaptation for basal attachment is shown by many lithistids, especially those of the families Anthaspidellidae and Chiastoclonellidae. These forms possess an imperforate epitheca, which covers the broadly conical basal surface. The basal epitheca generally bears concentric wrinkles which represent successive positions of the overhanging margin of the convex upper surface. The function of the imperforate dermal layer cannot be proved, but it seems likely that it covered the part of the sponge that was in direct contact with the substrate, and that the whole broadly conical base of the sponge was sunk into soft mud. Some specimens of *Defordia* and *Multistella* were initially attached to shells (see pl. 10, fig. 8). The shells were subsequently completely surrounded by the sponge, and the imperforate basal layer developed below this initial attachment. As the shell undoubtedly rested on the bottom, the subsequently formed basal surface must have penetrated well into the bottom. It is significant that the specimen of *Defordia defuncta* cited in the previous paragraph, which was probably supported above the bottom by a crinoid stem, assumed a nearly spherical form without a basal epitheca.

Many lyssacine hexactinellids, such as *Microstaura*, *Endoplegma*, *Polylophidium*, and *Stioderma*, had well-developed, long root tufts. As in the living hexactinellids, these forms must have lived on soft muddy bottoms, into which the long tufts projected.

A few of the sponges in the present collection lack any trace of a direct attachment to the bottom. The hexactinellid *Pileolites baccatus* has a flat basal surface which presumably rested directly upon the sediment. The prevalence of flat, sheet- or cake-like forms in this species is probably an adaptation for stability on the sea floor in the absence of a direct attachment. The spherical individuals of *Scheiia tuberosa* show no attachment and may have rolled about freely on the bottom if currents were present. It is noteworthy that a bun-shaped specimen of this species apparently remained fixed in one spot, for it has incorporated shell debris into its base (see pl. 33, fig. 7).

Dermal Strengthening

The lyssacine species *Stioderma coscinum* and *Docoderma rigida* show an adaptation for the strengthening of the skeleton which is developed to a degree unknown among other sponges. This is the presence of a rigid dermal layer formed by the lateral union of specialized dermal spicules. The interior spicules remain loosely united as in all other lyssacines. The manner in which these forms attained a strong and rigid skeleton differs radically from the solution to the same problem achieved by the dictyonine hexactinellids, the lithistid demosponges, and the pharetronid calcisponges. These latter forms, which were much more successful in terms of evolutionary survival, developed a skeleton that was completely fused throughout. The evolutionary trend that culminated in *Stioderma* and *Docoderma* had already begun as early as the Ordovician in the related form *Brachiospongia*. The structural development that they achieved apparently did not survive the end of the Paleozoic. A possible reason for the evolutionary "failure" of this side line of sponges may lie in the fact that they retained the ancestral lyssacine manner of growth. That is, the sponge increased in size by expansion of the whole body, the earlier formed spicules becoming more and more separated as newer ones were intercalated between them. As a result, the rigidly fused dermal skeleton could develop only in the last stages of growth, for once the spicules had united no further expansion was possible. In the other types of rigid sponges, a strong skeleton may be present from the beginning, for the sponge enlarges by the addition of uniform layers of fused spicules to the upper or outer surface of the body. That *Stioderma coscinum*, at least, did enjoy a temporary success is attested to by its wide occurrence in every environment in the Pennsylvanian and Permian of the mid-continent region. Its strong skeleton may have been the principal reason why it was able to inhabit the very shallow water environments of the shelf and reef facies.

Growth Form

The adaptive significance of growth form is a promising area of sponge study that has yet to be systematically investigated. The remarks of Bidder (1923) on the relation of growth form to water currents are summarized in the section on Individual Variation elsewhere in the present paper, together with possible examples of such adaptive forms from the collections studied here.

EPOECY AND SYMBIOSIS

Many specimens in the collection bear attached organisms which have, in turn, modified the shape of the sponge or have been partly overgrown by it. In such cases there is no doubt that both organisms were alive simultaneously. The neutral term "epoecy" is best used for these situations, for it avoids any inference as to the beneficial or harmful effect of the association upon the host. Some of these cases probably represent the fortuitous settling of a sessile animal upon a living sponge rather than upon some other element in the substratum. In other cases the association occurs with such regularity that the existence of a specific symbiotic adaptation is likely. The adaptation in these cases appears to be on the part of the adventitious organism, for the type of sponge involved seems to be a matter of indifference in some examples, and in every case it is difficult to imagine what specific benefit, if any, the sponge would derive from the association.

The chief value of such situations to the paleontologist is the evidence that they supply concerning the specific composition of the local fauna. There can be no question that we may be dealing with a death assemblage rather than with a living community. Even simple cases of attachment of one organism to another, without evidence that the substrate organism was alive at the time, can be used in reconstructing communities. If two sessile species occur at a locality, and each can be found attached to the other in separate examples, it is essentially certain that the two forms belonged to the same biologic community. Both types of evidence have been used here to reconstruct part of the biocoenosis at A.M.N.H. 512 (see below under Faunal Facies).

An example of an epoecious association between *Heliospongia vokesi* and a richthofeniid is illustrated in plate 4, figure 1. The sponge has almost entirely overgrown the attached brachiopod. This situation is not a regular occurrence, although more than one example is known. The majority of richthofeniids occur directly attached to shells on the sea floor, and the use of a sponge as a substrate was undoubtedly accidental. Several other brachiopod genera, such as *Leptodus*, *Meekella*, *Derbyia*, and some productids, have been found attached to various sponges under circumstances indicating that the sponge was alive at the time. These also must represent fortuitous associations. In the case of some of the Wolfcamp bioherms, the mutual intergrowth of the sponge *Coelocladiella philoconcha* and the brachiopods *Derbyia* and *Meekella* has led to the establishment of an important part of the reef framework, however accidental the initial association may have been (see pl. 8, fig. 2–4). Besides brachiopods, various massive, encrusting, and ramose (acanthocladiid) Bryozoa, as well as auloporoid and cladoporoid corals, have been similarly involved with living sponges. Various species of sponges have also been observed mutually to overgrow one another. A list of such associations observed at A.M.N.H. 512 is given below in the section on Faunal Facies.

Two specific associations of other organisms with sponges occur so frequently that they may involve a specific adaptation on the part of the adventitious organism. One of these is the epoecious association of a conularid, probably *Conularia leonardensis* or a related species, with a variety of sponge species in Leonardian and Guadalupian rocks. One such case, involving a species of *Guadalupia*, has been discussed by the writer (Finks, 1955). Subsequent examination of the Permian sponge collections has uncovered several additional occurrences. At P.U. 80c two external molds of a conularid are present in a specimen of *Haplistion aeluroglossa* and one in a specimen of *Actinocoelia maeandrina*. The conularids were embedded upright in the body of the sponge, perpendicular to its upper surface. (See pl. 19, fig. 10, and pl. 27, fig. 1.) At U.S.N.M. 705a an individual of *Defordia defuncta* contains two such molds having the same orientation (pl. 12, fig. 6). The position of the conularid molds makes it almost impossible to assume that the sponge overgrew a dead shell, and we must assume that the conularid was regularly sessile and settled on the living sponge. A similar sponge specimen is in the possession of Dr. G. Winston Sinclair, who has expressed the opinion (personal communication, 1955) that we may be dealing with a specific adaptation on the part of the conularid. As the sponges involved are so various and unrelated, it does not seem likely that the relationship involves an adaptation on the part of the sponge.

Another interesting association is the occurrence of the gastropod *Glyptotomaria marginata* in the cloacal cavity of *Heliospongia vokesi*. Such an example has been discussed by Batten (1958, p. 169) and is dealt with under the systematic description of *Heliospongia vokesi* in the present paper. That the snails found their way into the cloaca of the sponge while it was alive is clear from the fact that their shells became embedded in the sponge tissue that filled in the cloaca during subsequent growth. As in the case of the conularid, it is probable that the adaptations involved in this relationship, if any, were not on the part of the sponge.

FAUNAL FACIES

The term "faunal facies," as used in this discussion, designates a repeatedly observed association of fossil sponges in the rocks, in terms of the inferred environmental situation believed to have controlled their occurrence. The faunal units recognized have been made sufficiently inclusive so that there is a minimal doubt concerning the biological reality of the association. It is probable that, within the broader units defined here, there existed more specific biocoenoses which may have had mutually exclusive taxonomic compositions. As a hypothetical example: within the "Pennsylvanian shelf facies," which includes 13 genera of sponges, the actual biocoenotic associations on the sea floor may have involved several subgroupings, each adapted to more specific environmental conditions, and containing only a few of the 13 genera. Perhaps certain genera regularly occupied local depressions on the sea floor, while others were confined to local areas of shoaler water. If the sponge-bearing deposits were made in the depressed areas, the preserved faunule might include both the autochthonous fauna that occupied the depression, along with elements of the shoal-water fauna that were washed into the depression after death. Although such a fossil assemblage would not be truly equivalent to the biocoenosis at that particular locality, it would be representative of the broader association of the general shelf environment. In some instances, discussed below, it is possible to demonstrate that at least part of the faunule preserved in the rocks was autochthonous.

Two major suites of faunal facies can be recognized in the present material. One is a fauna dominated by calcisponges, with a subordinate element of siliceous sponges. The other is a fauna composed exclusively of siliceous sponges, including numerous hexactinellids. The first appears to be confined to sedimentary deposits made in shallower water environments. It is the only fauna present in the Pennsylvanian collections. In the Permian it is found in shelf, bank, patch-reef, and barrier-reef deposits, that is, essentially in the light, partly bioclastic limestones. The second faunal type is confined to dark, bituminous, frequently spiculiferous limestones, believed to have been deposited in deeper-water or basin environments. The calcareous sponges are confined to the former type of facies and the hexactinellids, with the exception of *Stioderma* and *Stereodictyum*, to the latter. The demosponges are most abundant and diversified in the latter type of facies, but several genera are common to both. At certain localities, discussed below, biohermal lenses of patch-reef type are surrounded by rocks of basin lithology. The collections taken from the rocks of basin type at these localities often contain an admixture of the shoal-water, calcisponge fauna. In most of these cases the basin type of faunal element can be shown not to have been transported far, and it is probable that the elements of the calcisponge fauna were washed into the deposit from the nearby shallow-water, patch-reef environment.

The shallow-water calcisponge fauna seems to have persisted in the area during the entire period with which this study is concerned. Most of the genera involved are quite long-ranging. The faunas of the true reefs are in most cases identical with those common to the whole shelf environment, although some species are presently known only from the reefs themselves, and may have become differentiated in response to this more specialized environment (see especially the Wolfcamp Patch-Reef Facies, below). The Pennsylvanian and Wolfcampian faunas of this facies type are very similar. At the beginning of the Leonardian new taxonomic elements appear in this facies alongside the older endemic forms. These probably immigrated into the region at this time. In the Guadalupian, the newer elements eventually become dominant over the older elements that were inherited from the Pennsylvanian faunas. The latter genera gradually disappear, so that the latest Guadalupian faunas (Capitan reef) consist almost exclusively of the newer element. *Maeandrostia*, *Girtycoelia*, and *Coelocladia* disappear from this fauna at the end of the Pennsylvanian; *Wewokella* disappears at the end of the Wolfcampian; *Heliospongia* and *Stereodictyum*, in the middle Leonardian; *Fissispongia*, at the end of the Leonardian; and *Girtyocoelia*, at the end of the lower Guadalupian (Brushy Canyon). The new elements, which appear more or less simultaneously at the base of the Leonardian, consist of pharetronid calcisponges and three species of *Guadalupia*. The latter genus, as well as the persistent "*Amblysiphonella*" (*Stylopegma*), gives rise to new genera and species during Leonardian and Guadalupian times, and nearly all the species persist thereafter to the end of the Guadalupian.

The basin fauna is not known in this area prior to the Leonardian. It is known mostly from Leonardian rocks, being very poorly represented in the Guadalupian collections. No trends can be recognized in the development of this fauna during the Permian.

Figure 7 summarizes the development of these two faunas in the area of the present study. The width of the bands representing each of the faunal types is proportional to the number of genera present at the time and may therefore indicate roughly the diversity of ecological niches occupied by the sponges. The area of overlap indicates those biotopes occupied by elements of both faunas.

The late Paleozoic sponge faunas of the south central United States existed in a succession of environments which became progressively more restricted in areal extent even as they became more diversified and differentiated from one another. From at least medial Pennsylvanian (Desmoinesian) times through the early Permian (Wolfcampian), shallow shelf seas occupied the mid-continent region more or less continuously, reaching from the southwestern states as far northeast as the Mississippi Valley region. The depth of water in these seas oscillated, as evidenced by cyclothemic sedimentation, and the sponges appear to have occupied a zone of moderate depth, at the transition between predominantly argillaceous and predominantly calcareous sedimentation (Newell, personal communication). Although this zone shifted back and forth with changes in sea level, it must have maintained a continuous existence, and conditions within it must have remained nearly constant. The sponge fauna is essentially uniform throughout the area in question and shows only slow secular changes, at the infraspecific and specific level. Undoubtedly other environments existed, such as the subsurface reef deposits of central Texas, but no sponge fossils are available from them.

In the Wolfcamp formation of the Glass Mountains in west Texas a new sponge biotope makes its appearance, namely, that of local patch reefs, now preserved as limestone bioherms interbedded with the more widespread calcareous shales. The sponge fauna of these reefs is distinctive but consists largely of new species of the same genera that occupied the area during the Pennsylvanian. In the inter-reef shales, as well as in the shelf limestones, the Pennsylvanian fauna continues in considerably reduced form. The sponge faunas up until this time are dominated by a variety of thalamid calcisponges and by demosponges of the family Heliospongiidae. The only new element introduced into the Wolfcamp fauna is the peculiar hexactinellid *Stereodictyum*, which is found in both the reef and inter-reef facies. The appearance of this new form may be connected with the development of the Delaware Basin, with its deeper and semi-stagnant waters, which supports a distinctive, silicisponge-dominated basin fauna in the later Permian.

At least as early as Wolfcamp times the tectonic events were initiated that were to create the deep Delaware Basin, with its marginal shelf areas that supported patch and barrier

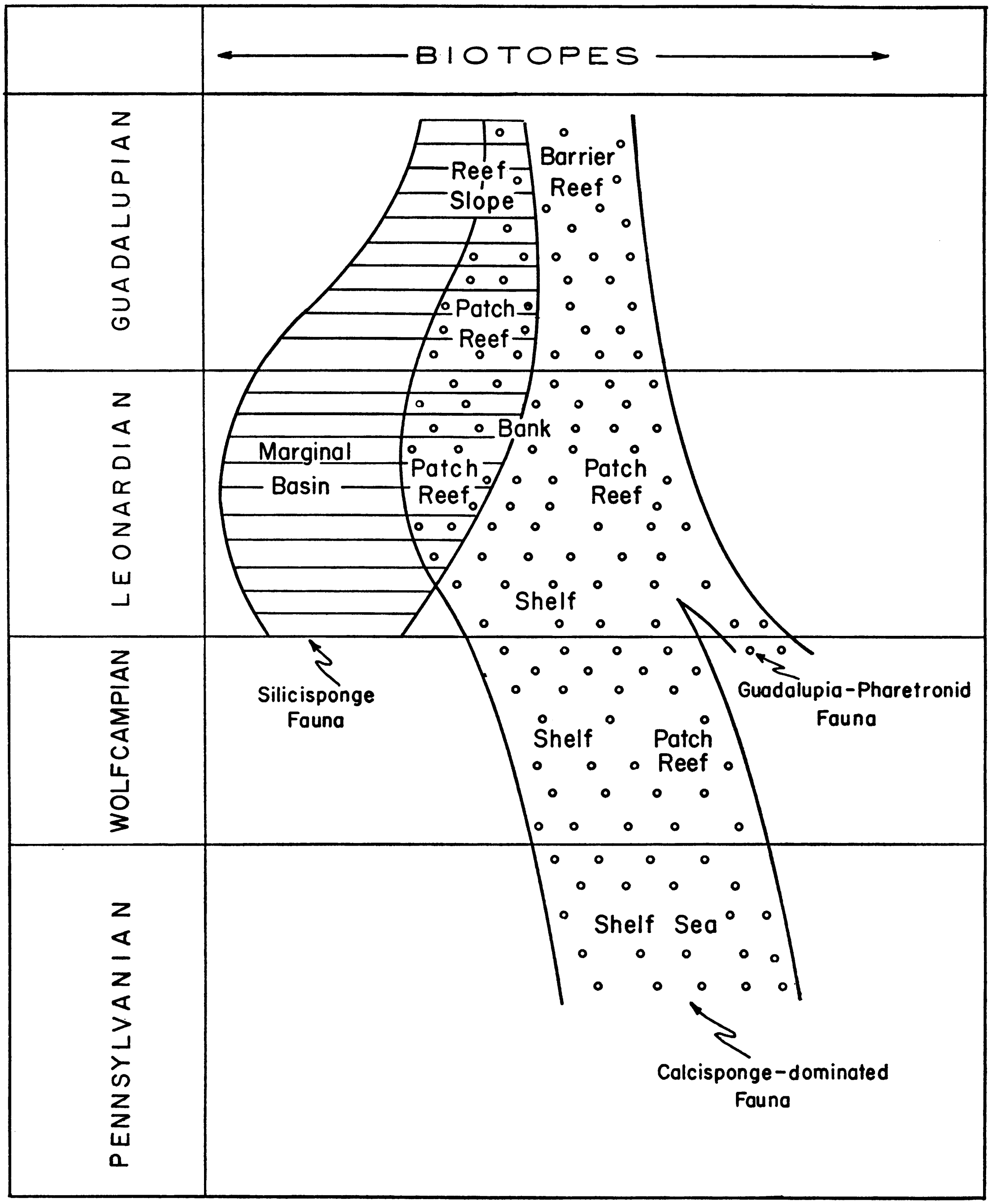
BIOTOPES
GUADALUPIAN
LEONARDIAN
WOLFCAMPIAN
PENNSYLVANIAN
Reef Slope
Barrier Reef
Patch Reef
Bank
Marginal Basin
Patch Reef
Patch Reef
Shelf
Silicisponge Fauna
Guadalupia-Pharetronid Fauna
Shelf
Patch Reef
Shelf Sea
Calcisponge-dominated Fauna

FIG. 7. Development of late Paleozoic sponge associations in the Texas region. Horizontal ruling represents the silicisponge "basin fauna" and small circles the calcisponge-dominated, shallow-water fauna. The horizontal dimensions are approximately proportional to the inferred diversity of ecologic niches occupied by each association, as based on the number of genera represented. The horizontal scale ranges from deeper-water, restricted-basin environment on the left to open shelf-sea, or platform, environment on the right.

reefs in Leonardian and Guadalupian times. The basin type of lithofacies, namely, dark shales and thin-bedded black limestones, was already present in this area during the Wolfcampian, but it is known only from wells, and no sponge fossils are available. In the medial Permian the area of shelf seas was progressively reduced by their retreat from the mid-continent region towards the west Texas area. The result of these events was the creation of contrasting environments of relatively restricted extent. During the Leonardian the basin environment was well established, and the depth of water in it has been estimated on stratigraphic grounds (Newell and others, 1953, p. 190) as approximately 500 feet. It was surrounded by shoal-water environments that may have supported patch reefs in the Glass Mountains area and did support a barrier reef in the Sierra Diablo region (King and Knight, 1944; Stehli, 1954). The margins of the basin area seem to have fluctuated, for, at least in the Sierra Diablo area, the shoal-water deposits of the upper Leonardian Victorio Peak formation extended basinward for some distance over earlier basin facies deposits, only to be succeeded by the basin type of deposit of the Cutoff shale which extended well onto the former shelf area. In the succeeding early Guadalupian (Brushy Canyon) time the depth distinction between the basin and the surrounding shelf was virtually obliterated, and the water depth over the whole region was probably less than 50 feet (Newell and others, 1953, p. 190). During the later Guadalupian the basin area became even more strongly differentiated than before, maintaining depths well in excess of 1000 feet (see Newell and others, 1953, pp. 190–191) and was margined at least in the Guadalupe Mountains area by a reef of barrier type, behind which was a shoal-water area. The back-reef zone became increasingly hypersaline as its areal extent decreased by the basinward retreat of the shore line. In latest Permian (Ochoan) times evaporite deposits covered the shelf, barrier-reef, and basin areas signalling the end of marine conditions in the region.

Parallel with the increasing differentiation of the physical environments in medial Permian times, a like differentiation of sponge faunas took place. We can recognize at least three distinct sponge associations, namely, a basin fauna, a shelf and patch-reef fauna, and a barrier-reef fauna. The basin fauna, in its typical development, consists entirely of siliceous sponges, including numerous hexactinellids. The shelf and patch-reef fauna is dominated by thalamid and pharetronid calcisponges, but certain species of demosponges have their most common or exclusive occurrence in this facies. The barrier-reef fauna appears to consist almost entirely of calcareous sponges. Where only patch reefs are developed along the basin margin, as in the Leonard and Word formations of the Glass Mountains and in the lower Getaway limestone of the Guadalupe Mountains, there is considerable mingling of the basin and shelf faunas.

At some patch-reef localities the actual collections seem to be from the apron of waste developed around the margins of the reef, which is surrounded in turn by a basin type of environment. The reef-facies elements of the fauna may have been washed down from the reef proper and mixed mechanically with autochthonous basin-facies forms. Such a situation has been suggested for the prolific localities A.M.N.H. 512 and U.S.N.M. 703c (Yochelson, 1956, p. 190).

On the other hand, where a continuous barrier reef is developed, as in the Leonardian of the Sierra Diablo and in the Guadalupian of the Guadalupe Mountains, the silicisponge basin fauna and the calcisponge reef fauna do not occur at the same localities. In the later Guadalupian, which is known only from the Guadalupe Mountains, the shelf fauna disappears entirely, probably because of the hypersalinity of the severely restricted shelf area.

The Leonardian shelf and patch-reef fauna contains a considerable element that seems to have been inherited from the Pennsylvanian shelf fauna, namely, the demosponge *Heliospongia* and several thalamid calcisponges such as *Girtyocoelia*, *Fissispongia*, and "*Amblysiphonella*." Added to these, however, is an important new immigrant element, previously unknown in the area, which includes the thalamid calcisponge *Guadalupia* and its relatives, as well as three genera of pharetronid calcisponges. The new element, together with species of "*Amblysiphonella*," is the only survivor of this fauna in the Guadalupian, and comprises essentially the entire barrier-reef fauna. Several new species of *Guadalupia* and "*Amblysiphonella*" appear at successive levels in the later Permian deposits. They seem to have been derived from the earlier forms and may well have evolved locally in response to the increasing diversification of the environment.

The basin fauna was probably present in the west Texas area during the Wolfcampian, but pre-Leonardian deposits of basin type are known only from the subsurface and bear no sponge fossils. A highly diverse assemblage of silicisponges is known from Leonardian rocks. In the Guadalupian the basin fauna appears to be much reduced in numbers of species, but this may be the result of less intense collecting.

Several silicisponge genera are common to both shelf and basin environments. Some of these appear to have had wide tolerances to environmental conditions, such as the rhizomorine *Haplistion* and the hexactinellid *Stioderma*, which are present in the shelf deposits of the Pennsylvanian and persist in nearly every facies of the Permian. Others, such as the tetracladine genera *Defordia* and *Actinocoelia* and the hexactinellid *Stereodictyum*, are most abundant and widespread in the shelf facies but also occur in basin deposits. These seem to have been better adapted to shoal-water environments but were able to range into at least the marginal basin areas. It is worth noting that *Defordia* and *Actinocoelia* have different species on opposite sides of the Delaware Basin during the Leonardian. This suggests that the basin environment was relatively unfavorable for these genera and served as a barrier between the shelf populations on the two sides (see also the discussion below under Geographic Variation). Still other forms, such as the lithistid sponges belonging to the family Anthracosyconidae, are most common in basin-facies deposits, but occur sporadically in shelf and reef deposits.

In general the calcareous sponges are confined to the shelf and reef facies and do not occur in rocks of basin type except at certain localities such as A.M.N.H. 512 and U.S.N.M. 703c where they may have been carried down as waste from nearby patch reefs. This class of sponges constitutes an important frame-building element in the patch and barrier reefs of the west Texas Permian. Most of the hexactinellid species, on the other hand, are confined to basin-facies lithologies. The only exceptions to this rule are the two widespread species *Stioderma coscinum* and *Stereodictyum orthoplectum*, which seem to have had a wider tolerance to environmental conditions. Of the demosponges, the monactinellid family Heliospongiidae is confined to the shelf and patch-reef facies, and the lithistids are in general equally abundant in rocks of the shelf and basin types. This distribution pattern coincides remarkably with the bathymetric distribution of the same groups at the present day. The rocks of the west Texas Permian are the oldest known deposits in which this pattern can be observed and checked against bathymetric data inferred from the physical stratigraphy.

The specific compositions of the various sponge associations are summarized below.

PENNSYLVANIAN SHELF FACIES

This sponge association is found in argillaceous limestone and calcareous shale lithotopes of Desmoinesian to Virgillian age. The sponges are associated with a rich fauna of mollusks (especially gastropods), brachiopods, crinoids, Bryozoa, solitary rugose corals, and calcareous algae. The sponges are frequently attached basally to shells, or crinoid stems, and occasionally to platy calcareous algae. The sponges often bear patches of encrusting Bryozoa, some of which were present while the sponge was alive, for they may modify the shape of the sponge locally. The water was relatively shallow, for the presence of algae indicates that the environment was well within the euphotic zone, probably within 15 meters of the surface. Turbidity, or at least rate of sedimentation, was probably relatively low, for the frequency of basal attachments of sponges to isolated brachiopod valves, as well as the common encrustations of shells and sponges by Bryozoa, suggests that burial was quite slow. This is a general summary of the whole environment; undoubtedly there were local variations in ecological conditions within this broad zone, as suggested by local variations in size and growth form of *Wewokella*, *Maeandrostia*, *Heliospongia*, and *Coelocladia*. Some genera are absent at several (not necessarily the same) localities, especially

Girtycoelia, *Girtyocoelia*, *Heliospongia*, and *Wewokella*, which may indicate more restricted tolerances of these forms to ecological conditions. "*Amblysiphonella*" is absent entirely before the Virgilian. *Fissispongia*, *Maeandrostia*, and *Coelocladia*, on the other hand, are present at nearly every locality that has a sponge fauna. The lithistid and hexactinellid genera are very sporadic in their occurrence.

The distribution of sponges, even within their general zone of tolerance, was probably very patchy. At most of the localities collected the sponges were very numerous and must have occupied a considerable proportion of the space available on the sea floor.

The sponge genera present in this facies include:

CALCAREA
  Heteractinida
    Wewokella
  Thalamida
    Cystauletes
    Fissispongia
    Fissispongiid, new genus A
    Maeandrostia
    "*Amblysiphonella*"
    Girtyocoelia
    Girtycoelia
DEMOSPONGEA
  Epipolasida
    Heliospongia
    Coelocladia
    Coelocladiella
  Rhizomorina
    Haplistion
    Chaunactis
HEXACTINELLIDA
    Stioderma

WOLFCAMPIAN SHELF FACIES

Under this heading is included the fauna of the Wolfcamp and Hueco formations in all their lithofacies except that of the limestone bioherms of the Wolfcamp. The latter includes some distinctive forms and is treated as a separate faunal facies. Apart from these bioherms, the Wolfcampian rocks that bear sponges include (1) calcareous shales in the type area of the Wolfcamp formation, (2) evenly bedded dolomitic limestones of the upper Hueco formation and of the Hess facies of the Wolfcamp formation, and (3) limestone conglomerates of the Wolfcamp formation. In terms of genera the sponge fauna represents a very much restricted continuation of the Pennsylvanian shelf fauna. Most of the species, however, are new. The chief new genus is the hexactinellid *Stereodictyum*, which is probably the most abundant and widespread sponge in the Wolfcampian rocks. Two lithistid types, which become much more abundant in the later Permian rocks, make their first appearances here in single occurrences; these are the genus *Defordia* and an anthracosyconid probably belonging to the genus *Collatipora*. The Pennsylvanian genera *Girtycoelia*, *Maeandrostia*, and *Coelocladia* are entirely absent from Wolfcampian and later rocks. *Wewokella*, "*Amblysiphonella*," *Fissispongia*, and *Girtyocoelia*, however, are still present, and all but *Wewokella* are abundant in the succeeding Leonardian rocks. The associated fauna, and the general environment, of the Wolfcampian shelf facies were probably very similar to those of the Pennsylvanian shelf facies.

The composition of the sponge fauna is as follows:

CALCAREA
  Heteractinida
    Wewokella ("*Talpaspongia*")
  Thalamida
    Fissispongia
    "*Amblysiphonella*" *prosseri*
    "*Amblysiphonella*" (*Stylopegma*) new species A
    Girtyocoelia
DEMOSPONGEA
  Epipolasida
    Heliospongia
  Tetracladina
    Defordia
    ?*Collatipora*
HEXACTINELLIDA
    Stereodictyum

WOLFCAMP PATCH-REEF FACIES

In the Wolfcamp formation of the Glass Mountains, there occur numerous lenses of biohermal limestone (U.S.N.M. 701, 701a, 701c, 701h, 701k, 701-l, and 715d) in which sponges are an important element. Patch reefs of similar appearance are abundant in the Hueco formation of the Sierra Diablo, but no collections are available from them. If one may judge from the acid-prepared blocks of limestone from these bioherms, in which the fossils are silicified, as well as from polished sections of unsilicified blocks, the sponges make up nearly half of the bulk of the rock and, together with laminar calcareous algae, were the chief frame builders of the reefs. Brachiopods, especially the genera *Derbyia* and *Meekella*, constitute a large proportion of the remaining fauna and also enter into the frame of the reefs. The brachiopods and the sponges mutually overgrew each other while both were living and formed a continuous rigid framework (see pl. 8, figs. 2–4). Fenestrated Bryozoa also entered into the reef mass, and numerous other shelled invertebrates, especially gastropods, were present. The chief sponges involved in these reef masses are *Fissispongia*, three new genera of fissispongiids, a new species of "*Amblysiphonella*" (*Stylopegma*) different from another which is found in the surrounding inter-reef shales, *Coelocladiella philoconcha*, and *Haplistion megalochetus*. *Heliospongia vokesi* and *Stereodictyum orthoplectum* are also present but are volumetrically less important in the blocks available for study. At each locality, or at least in each block examined, only one of these species makes up the main part of the reef framework. Individual species, therefore, tended to occur in dense patches, although it remains to be demonstrated whether whole patch reefs were thus constituted of a single sponge type. Except for *Fissispongia*, the species that built these reef masses are not found in the surrounding inter-reef shales. In the case of "*Amblysiphonella*" it seems likely that the differentiation of two closely related species, one confined to the reefs and the other to the inter-reef deposits, was brought about by adaptation to the reef environment.

The sponge fauna found in these patch reefs includes the following species:

CALCAREA
  Thalamida
    Fissispongia sp.
    Fissispongiids, new genera A, B, C
    "*Amblysiphonella*" (*Stylopegma*) new species B
DEMOSPONGEA
  Epipolasida
    Heliospongia vokesi
    Coelocladiella philoconcha
  Rhizomorina
    Haplistion megalochetus
HEXACTINELLIDA
    Stereodictyum orthoplectum

LEONARDIAN SHELF AND PATCH-REEF FACIES

The shoal-water sponge populations of the Leonardian seem to have been relatively uniform, although they occupied a variety of sedimentary environments. It is not possible to recognize consistent differences between the faunas of such different environments as the lime-mud shelf areas represented by parts of the Leonard and Kaibab formations, the shell-bank facies of the Victorio Peak formation, the near-shore facies of the lower Bone Spring formation in the Sierra Diablo and the back-reef facies of the higher beds of the same formation, or the patch-reef areas of the Leonard. The fauna is dominated by calcisponges. Most of the genera represented belong to the Order Thalamida and, except for the abundant *Guadalupia* and a new fissispongiid, were inherited from the Pennsylvanian shelf faunas. An important faunal element, in terms of abundance of individuals, is three genera of pharetronid calcisponges, which appear here for the first time and indeed represent the oldest known occurrence anywhere in the world of this typically Mesozoic group of sponges. Another holdover from the Pennsylvanian shelf seas is the demosponge *Heliospongia*, which is entirely confined to the shelf facies and disappears well before the end of the Leonardian. The remaining genera of siliceous sponges represented here are also present in the contemporaneous basin facies, although the genera *Defordia* and *Actinocoelia* seem to be more abundant in the shelf environment than at basin-facies localities. The known Leonardian faunas of both shelf and basin environments are much more highly diversified taxonomically than those from earlier and later horizons, certainly owing in part to the more intensive collecting carried on in the Leonardian rocks, but also the abundance of sponges at the outcrops suggests that the environments of this area during Leonardian times were more favorable for sponge growth than at other times.

Sponges are not equally common at all the localities from which large quantities of acid-prepared silicified material are available. This circumstance would seem to reflect a patchy distribution of the living sponges on the sea floor. The Leonardian shelf-facies localities that are most prolific in sponge fossils are U.S.N.M. 702, 702d, 703a, 703b, 703c, and 705a. At these localities the sponges make up a large proportion of the volume of total fossils available. Some of these concentrations may have been effected by water-current action after the death of the sponges. For example, U.S.N.M. 702 has been interpreted by Batten (1958, p. 168) as an accumulation of transported shells in a current-scoured depression. However, although many of the shells at this locality appear to be broken and wave-worn, the majority of the sponges are large and relatively unbroken. If they were transported, the distance cannot have been very far, and the richness in species of the sponge fauna present surely indicates an abundant population of sponges in the immediate vicinity. The same observations are equally true of the other localities listed. On the basis of field evidence, Cooper and Batten (see Batten, 1958, p. 169) interpret the fauna of U.S.N.M. 702d as being essentially in place. This conclusion is borne out by the occurrence of the sponges in massive clumps, each mass consisting of a single species. This is especially true of *Heliospongia vokesi*, *Girtyocoelia dunbari*, and a new species of fissispongiid (genus D). At this locality, and probably at most of the others, the sponges must have occupied a considerable proportion of the space on the sea floor. The relative abundance of individual genera varies somewhat from one locality to another, but at all but one of them the genera *Guadalupia*, "*Amblysiphonella*," *Fissispongia*, *Girtyocoelia*, and pharetronid genus A together constitute a majority of the total volume of sponges. The single exception is U.S.N.M. 705a, which is a lower horizon than the others. Here *Heliospongia vokesi* and *Defordia defuncta* are the most abundant species. This exception may be due to an environmental difference or may indicate that the genera abundant at the higher levels, although already present, had not yet begun to flourish. Leonardian occurrences of *Heliospongia vokesi* in the Glass Mountains are essentially restricted to the Hess lithofacies; in the Sierra Diablo this species occurs in the reefy beds of the lower Bone Spring formation. Possibly these lithofacies represent environments of somewhat shoaler water than the other parts of the Leonardian shelf areas.

The invertebrate fauna associated with the sponges of the shelf facies is quite rich and varied. Brachiopods are very numerous and include abundant coralliform richthofeniids as well as leptodids. Fenestrated and branching Bryozoa are especially abundant. Considerable numbers of small, solitary, rugose corals are generally present, but colonial rugosa are essentially absent. Numerous mollusks are present, including many gastropods, pelecypods, scaphopods, and cephalopods. Crinoids are common; eleutherozoan echinoderms and trilobites are present but relatively rare. The sea bottom in many of these areas may have been relatively shelly, which is suggested by the dense packing of the shells in the acid-prepared blocks as well as by the frequency of basal attachments of sponges and richthofeniid brachiopods to shells. The whole environment must have been densely populated, and the larger sponges frequently bear attached sessile invertebrates, such as Bryozoa, brachiopods, corals, and other sponges, especially *Girtyocoelia* and *Fissispongia*. Many of these appear to have grown on the living sponges.

The sponge genera characteristic of this facies are as follows:

- CALCAREA
  - Pharetronida
    - New genus A
    - New genus B
    - *Virgola*
  - Thalamida
    - *Guadalupia*
    - *Fissispongia*
    - Fissispongiids, new genera A, B, and D
    - *Girtyocoelia*
    - "*Amblysiphonella*" (*Stylopegma*)
    - Amblysiphonellid, new genus
- DEMOSPONGEA
  - Epipolasida
    - *Heliospongia*
  - Tetracladina
    - *Insulipora*
    - *Defordia*
    - *Actinocoelia*
    - *Jereina*
    - *Anthracosycon*
  - Rhizomorina
    - *Haplistion*

Eutaxicladina
  Scheiia
HEXACTINELLIDA
  Stereodictyum
  Stioderma

GUADALUPIAN SHELF AND PATCH-REEF FACIES

This fauna is known chiefly from Word limestone numbers 2 to 4 in the Glass Mountains and from the lower Getaway limestone of the Guadalupe Mountains. It is essentially a continuation of the similar Leonardian fauna but is much reduced in variety and contains some new forms. Among the calcisponges, *Fissispongia* and its close relatives are absent, and *Girtyocoelia* is absent above Word limestone number 2. The three genera of pharetronids persist in force, and both *Guadalupia* and "*Amblysiphonella*" are abundant, with two new species of the former and one of the latter appearing alongside some of the species that persist from the Leonardian. The genus *Cystothalamia* first appears in rocks of Cherry Canyon age and thenceforth is an important element of the fauna. It seems to have been derived from a species of *Guadalupia* close to *G. zitteliana* Girty. Most of the characteristic Leonardian siliceous sponges are absent, *Heliospongia* and *Stereodictyum* having disappeared well before the end of the Leonardian.

The environments occupied by this fauna were probably very similar to the equivalent ones of the Leonardian. The locality from which the most information is available is A.M.N.H. 512 (U.S.N.M. 728), which is a patch reef in the lower Getaway limestone, surrounded by sediments of basin lithology. The available collections were made on the flanks of the reef mass, perhaps in the zone of reef talus. Mutual overgrowth of several sessile forms provides very precise data on part of the actual biocoenosis at this locality. The following forms either show evidence of mutual overgrowth while both forms were alive or else specimens of each have been found encrusting specimens of the other:

SPONGES
  Guadalupia
  Cystothalamia
  Virgola
  Pharetronid genus A
  Collatipora
  Tetracladine lithistid
COELENTERATES
  Conularia
  Acaciapora
  Solitary rugose coral
BRYOZOANS
  One massive trepostome and two encrusting species
BRACHIOPODS
  Meekella
  Leptodus
  Productid
ANNELIDA
  Spicule-lined tubes of an agglutinating wormlike form

The bottom at this locality was almost certainly quite shelly. Numerous specimens of the pharetronid sponge *Virgola* have been revealed *in situ* in the etched material, where they can be seen to ramify, in repent position, among the close-packed shelly debris, incorporating quantities of the shells into the basal portions of their skeletons. Many of the shell fragments are broken or worn, which indicates considerable agitation of the water. However, much of this material may have been washed down from the higher parts of the reef. Most of the sponges may have lived on the higher parts of the reef also, but *Virgola* clearly lived at the site of the collecting locality as well.

The following sponge genera are found in the Guadalupian patch-reef faunas:

CALCAREA
  Pharetronida
    New genus A
    New genus B
    Virgola
  Thalamida
    Guadalupia
    Cystothalamia
    "*Amblysiphonella*" (*Stylopegma*)
DEMOSPONGEA
  Tetracladina
    Multistella
    Collatipora
    Chiastoclonellid, undetermined
    Two undetermined tetracladine species
HEXACTINELLIDA
    Stioderma

BASIN FACIES

This sponge facies is essentially confined to thin-bedded, fine-grained, dark limestone lithofacies, such as the Bone Spring limestone of the Sierra Diablo-Guadalupe Mountains region, certain beds of the Leonard and Word formations of the Glass Mountains, the lower Getaway limestone of the Guadalupe Mountains, and the basin limestone tongues in the Bell Canyon series of the Guadalupe Mountains. The specific beds from which sponges have been obtained are highly bituminous and frequently yield considerable free petroleum when dissolved in acid. They are also densely crowded with isolated spicules and spicule fragments, which may make up a considerable proportion of some layers (see pl. 33, fig. 8). At some localities a variable amount of clay is present in the sediment, but in general there is very little terrigenous detritus.

The environmental interpretation of this facies is bound up with the general problem of organic-rich muds. Observations of such deposits in recent seas, as well as studies of their occurrence in the geologic record, have shown quite clearly that they may be formed in a variety of environments. Dunbar and Rodgers (1957, pp. 26–27, 202–208) have summarized much of the available knowledge concerning these deposits. The presence of organic matter in a sediment indicates a rate of supply of such material which is greater than the rate of its removal. The supply may come from the local biota or it may be carried in from elsewhere as fine detrital particles of organic material. Its removal is dependent, in the last analysis, on the conversion of the carbon into gaseous compounds, such as carbon dioxide and hydrocarbons, which will escape from the bottom sediment. This process may take place directly through reaction of the organic matter with the free oxygen dissolved in the water. It may also take place indirectly through the consumption of the organic material by bacteria, or by scavenging and mud-eating animals, which then convert the carbon into gaseous compounds in the course of their metabolic processes. Except in the case of anaerobic bacteria which produce gaseous hydrocarbons, the presence of free oxygen is necessary for these destructive processes. Because the free oxygen of the water is derived chiefly from diffusion of this gas from the atmosphere into the surface water, any restriction of the circulation of the water between the surface and the bottom will lead to the permanent accumulation of organic matter in the sediment. However, in the presence of a copious supply of organic matter, and its rapid burial, anaerobic conditions may prevail in the subsurface mud, even though the water and the sea floor itself are well aerated. Thus it is not necessary to assume stagnant conditions of the water in order to account for the permanent accumulation of organic-rich sediment. Some organic muds of today are being formed in areas of stagnant water, but others have accumulated in shallow and well-aerated parts of the sea floor. (See Dunbar and Rodgers, 1957, *loc. cit.*, for examples.) The geologic record provides similar examples. The west Texas Permian in particular would seem to exhibit both types of environments, purely on the basis of the physical stratigraphy. The organic deposits of the Delaware Basin of later Guadalupian times formed in a restricted basin the depth of which has been estimated as greater than 1500 feet (Newell and others, 1953, p. 190) by the tracing of individual horizons from the shallow-water reef margin down the fore-reef slope into the equivalent basin deposits. Other deposits of similar lithofacies, however, such as those of the lower Getaway limestone and Word limestone number 1, grade laterally into small patch-reef lenses, which implies a relatively uniform and shallow depth of the sea floor.

The sponge faunules examined in the present study tend to confirm the conclusion that some of these deposits were not formed in stagnant waters. Most of the faunules available from localities in the Bone Spring limestone, in Word limestone number 1, and in the lower Getaway limestone, were almost certainly buried in place. As sponges are strictly aerobic organisms, the waters must have been well aerated at the time they were alive. For example, at U.S.N.M. 703c there are numerous entire individuals of very fragile hexactinellids, such as *Microstaura*, *Polylophidium*, and *Carphites*, which could not have been transported very far without disintegrating. The clump of sponges at P.U. 80c (see pl. 19, figs. 8–10) seems also to be autochthonous, for many of the individual sponges are molded to one another, and the specimen of *Pileolites* at the lower left of figure 10 is basally molded to the shell immediately to the right of it, from which it has become only slightly separated.

Further evidence is provided by the occurrence, at several of these localities, of delicate tubes, built of spicules, which were obviously agglutinated by some worm-like creature. Such tubes have been found in considerable numbers at A.M.N.H. 480 in the Bone Spring limestone, at U.S.N.M. 703c in Word limestone number 1, and at A.M.N.H. 512 in the Getaway limestone. The excellent preservation of these fragile constructions, and their constitution out of the same spicules that make up much of the surrounding sediment, are clear evidence of their autochthonous nature. These worms, which occur in considerable numbers, likewise could not have lived in a completely anaerobic environment.

The localities in the Bell Canyon limestone tongues, on the other hand, were almost certainly in deep, stagnant water. The deposits were made on the floor of the Delaware Basin, which at that time was probably 1500 to 1800 feet below sea level (see Newell and others, 1953, p. 190). Stratigraphic evidence strongly suggests that the sediments and their contained fossils were carried down from the reef flanks into the deeper waters of the basin (Newell and others, 1953, pp. 49 ff.). The sporadic nature of the sponge occurrences in these beds, and the fragmental nature of the more delicate forms, agree with the interpretation of an allochthonous origin.

The basin fauna in general probably represents those sponge populations that lived in the quieter and deeper but still well-aerated parts of the sea floor, chiefly on the flanks of the patch and barrier reefs or on the surrounding sea floor. Its taxonomic composition, as in all faunal associations, was determined by the individual ecological tolerances of its component elements. The calcisponges were absent, probably because the depth of the water was too great for their light or temperature requirements. The lithistid demosponges, which also occur sporadically within the reefs themselves, were able to flourish here because they were not crowded out by the Calcarea, as well as by the other sessile reef organisms which were restricted to a shelly bottom. The more delicate hexactinellids were probably restricted to this environment because of their need for relatively quiet water.

The basin fauna consists entirely of siliceous sponges, and the Permian hexactinellids, except for *Stioderma* and *Stereodictyum*, are confined to this facies. The fauna as a whole is richest in Leonardian rocks. Only *Anthracosycon*, *Collatipora*, and *Stioderma* persist into the Guadalupian. One new form, the peculiar hexactinellid *Stromatidium*, appears in the Guadalupian. The meagerness of the later basin fauna may in part be due to the less intensive collecting from the higher beds. However, it may also reflect a reduction of the available areas of quiet but non-stagnant water, in which this fauna lived. The increasing deepening, and resulting stagnation, of the Delaware Basin during Guadalupian time probably restricted such environments to a relatively narrow zone along the basinward flanks of the barrier reefs.

The faunules from specific localities show considerable differences in composition, a circumstance that may indicate local differences in the environment. The richest faunules are discussed separately below.

LOCALITY P.U. 80C

This faunule was obtained from a small block of limestone collected from the very base of the Bone Spring formation in the Sierra Diablo. The block consists entirely of a mass of sponges in their original growth position and despite its small size contains a great variety of species. It indicates more than any other collection what a basin facies sponge biocoenosis was like. Three views of the etched block, after some of the specimens had been removed, are illustrated on plate 19, figures 8–10. The clump contains 42 individual sponges distributed taxonomically as follows:

SPECIES	NUMBER OF INDIVIDUALS
Pileolites baccatus	15
Haplistion aeluroglossa	13
Cf. *Actinocoelia maeandrina*	4
Anthracosyconid, cf. *Collatipora* sp.	5
Dactylites micropora	3
?Chiastoclonellid	2
Isolated hexactinellid spicules and root-tuft fragments	—

The orientation of the mass has been determined from the manner in which some of the sponges have been molded to the shapes of those beneath them. Some of the sponges are clearly lying on their sides, especially the digitate sponge *Dactylites*, the largest specimen of which was removed from the block and is illustrated on plate 24, figures 1 and 2. Several of the individuals of *Pileolites*, which have a relatively narrow base and no root tuft, are completely overturned. These circumstances, together with the presence of abundant fragments of large, probably root-tuft, monaxons, which fill most of the interstices between the sponges, suggest that there was at least occasional agitation of the water. It is possible that this faunule was from shallower water than other basin-facies localities where delicate hexactinellids, represented here only by isolated spicules, are preserved entire. Little else is present in this block besides sponges. There are a few fragments of shells, probably brachiopods, which were washed in by currents. The only other form present is a conularid, probably *Conularia leonardensis*, which is represented by two external molds in a specimen of *Haplistion* and one mold in a specimen of *Actinocoelia*. These probably lived symbiotically on the sponges, an interesting relationship which is discussed elsewhere in this paper.

LOCALITIES P.U. 1R AND P.U. 1RC

These localities appear to lie at the basinward margin of the reef talus from the Bone Spring barrier reef in the Sierra Diablo. The sponges are numerous and represented by large individuals, but only a few species dominate the fauna. These are the lithistid *Defordia densa* and the hexactinellids *Dococerma papillosum* and *Carphites diabloensis*. Large fragments of root tufts, probably belonging to the last two species, make up a considerable proportion of the sediment. The sea bottom here may have been relatively soft and muddy, for the dominant sponges are forms with adaptations for attachment to soft sediment, namely, the root tufts of the two hexactinellids and the imperforate basal epitheca of *Defordia*.

LOCALITY U.S.N.M. 703C (A.M.N.H. 503)

This locality, in Word limestone number 1 of the Glass Mountains, has the richest faunule of all the basin-facies localities. Apart from the lithistids *?Collatipora pyriformis* and *Haplistion aeluroglossa*, which are represented by numerous specimens, the faunule is dominated by a great variety of hexactinellids, many of which are quite fragile. The locality is in the immediate vicinity of a patch reef, bearing a rich calcisponge fauna, which is surrounded by rocks of basin lithology. It is probable that the hexactinellid fauna occupied the flanks of the reef, with the more delicate types living in sheltered spots of quieter water. The acid-etched blocks from this locality appear to include portions of the patch reef itself, bearing a patch-reef calcisponge fauna, as well as portions of the surrounding quieter water deposits. The blocks from which the more delicate sponges were obtained contain numerous loose spicules, but for the most part they are not crowded in the rock, and the bottom was probably quite soft lime-mud. The autochthonous nature of this faunule, and the relative quietness of the water, are attested to by the presence of numerous entire specimens of the delicate hexactinellids *Polylophidium* and *Microstaura*, including various ontogenetic stages of the latter, as well as by the presence of entire crinoids, in which the long stems and arms are completely articulated. The hexactinellid species present include: *Microstaura doliolum*, *Endoplegma calathus*, *Polylophidium discus*, *Docoderma rigida*, *Carphites plectus*, *Acanthocoryna stauroma*, and lyssacine species 1, 2, and 3.

The basin-facies fauna in general is summarized below. Except where otherwise indicated, the genera are confined to Leonardian localities.

CALCAREA (None)
DEMOSPONGEA
  Tetracladina
    Defordia
    Actinocoelia
    Jereina
    Anthracosycon (Leonardian and Guadalupian)
    Collatipora (Leonardian and Guadalupian)
    Dactylites
  Rhizomorina
    Haplistion
  Eutaxicladina
    Scheiia
HEXACTINELLIDA
    Microstaura

Endoplegma
Stereodictyum
Polylophidium
Docoderma
Carphites
Acanthocoryna
Stioderma (Leonardian and Guadalupian)
Stromatidium (Guadalupian only)
Pileolites
Lyssacine species 1, 2, and 3

A great many, perhaps a majority, of the beds in the basin lithofacies contain large quantities of isolated small spicules and spicule fragments, although no coherent sponge skeletons can be found. A minority of these spicules are hexacts, but most of them are oxeas. The broken nature of some of the spicules suggests that they were transported for some distance, but the wide occurrence of such sediments in the basin lithofacies also suggests that the habitat of the sponges that supplied the spicules was in some part of the basin environment. Newell and others (1953, p. 197) have assumed that the oxeas were derived from monactinellid demosponges. Unfortunately it is not possible to demonstrate that such is the case, for many lyssacine hexactinellids contain similar monaxonic spicules. It is theoretically possible to distinguish the oxeas of demosponges from those of hexactinellids by the presence, in the latter, of an axial cross in the central canal of the spicule, which represents the aborted rays of the fundamental triaxon. Examination of numerous oxeas from several basin-facies localities failed to demonstrate such axial crosses, which suggests that the spicules were indeed from demosponges. However, this evidence is by no means conclusive, for the axial canals are poorly preserved in most of the spicules, and the axial cross is difficult to observe even in well-preserved material. The occurrence of true hexacts in the same sediments indicates that hexactinellids were certainly present, whatever the origin of the oxeas may have been.

GEOGRAPHIC VARIATION

Replacement of one species, or infraspecific variant, by a contemporaneous related form in a different geographic area can be observed among the Texas sponges in several instances. In each instance in which the number of available localities and specimens suggests that we are not dealing with a random sampling error, parallel variations can be observed in unrelated groups. To what extent these variations are controlled by environmental conditions is not clear, but the fact that they are somewhat independent of the sedimentary environments inferred from lithologic evidence, as well as the fact that they persist in the same area through successive horizons, suggests that the geographic separation in itself may be a controlling factor.

In the Leonardian rocks of the Delaware Basin region several genera are represented by different species on the northwest and southeast sides of the basin. In the Sierra Diablo-Guadalupe Mountains area on the northwest margin of the basin, *Actinocoelia maeandrina* and *Defordia densa* are common faunal elements of both the shelf (Victorio Peak) and marginal basin (Bone Spring) environments. In the shelf and patch-reef environments of the Glass Mountains, on the opposite side of the basin, these species are replaced by *?Actinocoelia verrucosa* and *Defordia defuncta*, respectively. The hexactinellid genera *Docoderma* and *Carphites* of the same areas present a less clear-cut case of geographic distribution. In the marginal basin facies of the Sierra Diablo, *Docoderma papillosum* and *Carphites diabloensis* form an important element of the sponge fauna. At U.S.N.M. 703c, in the Glass Mountains, which represents a mixed basin and patch-reef fauna, the species *Docoderma rigida* and *Carphites plectus* occur. However, some doubt exists as to the absolute restriction of these species to their respective areas, for a single dermal spicule of *Docoderma rigida* type has been found in the Sierra Diablo, and a single doubtful specimen of *Carphites diabloensis* occurs in the Glass Mountains. It is possible, at least in the cases of the first two genera, that the deep and stagnant waters of the Delaware Basin and Hovey Channel, which separated the two areas during and prior to Leonardian times and which could not be colonized by these sponges, served as a reproductive barrier between the populations of the opposite sides. This interpretation assumes that the larval stages of these sponges were sufficiently short for their transportation across the intervening waters to be not possible. Several sponge species are common to both sides of the basin and were not thus affected by the presumed barrier. Among them are *Heliospongia vokesi*, *Jereina cylindrica*, *Anthracosycon regulare*, *Haplistion aeluroglossa*, *Microstaura doliolum*, *Stereodictyum orthoplectum*, *Stioderma coscinum*, and *Pileolites baccatus*.

The middle Missourian rocks of the midcontinent area show a more localized variation at the infraspecific level. In the vicinity of Bridgeport, in north central Texas, *Heliospongia excavata* is represented by strongly flabellate forms with abundant lateral cloacae, and *Coelocladia spinosa* is represented by numerous funnel-shaped forms. In all other areas with rocks of the same age, ranging from the Glass Mountains on the southwest to Kansas City on the northeast, *Heliospongia* is represented by forms comparable to *H. excavata* but which lack the strongly developed flabellate form and lateral cloacae, and *Coelocladia spinosa* occurs only in the cylindrical growth form. The flabellate type of *Heliospongia* was already present in the north central Texas area in early Missourian time (Palo Pinto limestone). Unfortunately, *Heliospongia* is not known from any other lower Missourian locality, and *Coelocladia* is not known from the Palo Pinto limestone. It is possible that the peculiar growth forms of these two species in the north central Texas area reflect special environmental conditions there (see the next section, on Individual Variation).

INDIVIDUAL VARIATION

Students of living sponges observing large populations in the field soon become aware of the tremendous range of growth form that a single species may exhibit. The extensive programs of mass etching of silicified fossils carried out at the American Museum of Natural History and at the United States National Museum, from which most of the material for the present study has been obtained, have made available equivalent samples of fossil populations. These have provided a splendid opportunity for observing similar variation among fossil sponges, as well as an object lesson in the pitfalls that await the paleontologist when he is forced to deal with the more casual collections commonly brought in by the field stratigrapher.

Individual variation in growth form among living sponges can in some instances be identified as responses to specific environmental conditions, especially to the degree of agitation of the water or to the existence of constant currents. Such information is of great use to the paleontologist in his attempts to reconstruct ancient environments. Other variation between individuals may be caused only by the exigencies of the available space. A third potent source of individual variation among sponges is ontogenetic change, which may produce surprisingly great differences in external form. Several instructive examples, which possibly include all three of these types, are provided by the material of the present collections.

Some of the environmental factors influencing the growth form of living sponges have been analyzed by Bidder (1923). He points out that the principal physiological problem faced by a sponge is the separation of the excurrent stream of waste material from the fresh water taken in by the sponge through its pores. This problem is minimal in agitated water in which the currents themselves soon dissipate the waste material. Sponges in such environments very often lack cloacae, their chief problem being to present as great a pore-bearing surface area to the moving water as possible. In such cases the excurrent pores are often located on the surface of a broad cup. In quieter water it is necessary for the sponge itself to concentrate the excurrent stream of water, so that it is projected for a considerable distance away from the sponge. The concentration is accomplished by the development of a cloaca which opens at the top of the sponge in a more or less constricted osculum. At the same time the sponge may develop a stalk, so that the ambient zone available for the circulation of fresh water to the base of the sponge is increased. In environments where there are currents of constant direction, the sponge may develop a flabellate form oriented transverse to the current, with the incurrent surface on the upstream side and the excurrent surface on the other.

In the Graford formation localities in the vicinity of Bridgeport, Texas, *Coelocladia spinosa* occurs in two general growth forms. One is the cylindrical, cloacate form, usually ramose, which is the only one found at all other localities from which the species is known. This form may be adapted to relatively quiet waters, for the reasons given in the analysis by Bidder cited above. It is worthy of note that the most common faunal associates of *Coelocladia* are *Heliospongia*, *Maeandrostia*, *Wewokella*, and *Fissispongia*, which have nearly identical growth forms. At the locality cited, however, *Coelocladia* also occurs in funnel-shaped forms, produced by the upward flaring of the cylinders. These often open out asymmetrically into a curving sheet, with the excurrent surface on one side and the incurrent on the other. (See pls. 5 and 6). Possibly these are related to the presence of local constant currents of water occasioned in this area by some special geographic situation. Such an inference receives some support from the fact that at the same localities *Heliospongia excavata* shows its most strongly developed flabellate form. As can be seen from plate 1, figure 3, the fronds tend to be oriented in the same direction, which may have been transverse to the current. In this case incurrent and excurrent surfaces are not located on opposite sides of the frond, but an advantage would still be gained in presenting as great an area of incurrent pore surface as possible to the food- and oxygen-bearing currents of water.

Actinocoelia maeandrina, which is common in the Victorio Peak, Bone Spring, and Kaibab formations, also occurs in two growth forms, frequently at the same locality. One is a cylindrical form which seems to have grown upright (pl. 16, figs. 6–9). The other is a flattened, bun-shaped form (pl. 16, figs. 4 and 5). Although the sponges of the latter shape are commonly found in the rock with their flat surfaces parallel to the bedding plane, the construction of the sponge would seem to indicate that the flat dimension grew perpendicular to the bottom, for the basal growing point is at one narrow edge and the oscules are at the opposite edge (see pl. 16, figs. 4 and 5, and pl. 17, fig. 1). Such a form would correspond more or less to a flabellate sponge such as *Heliospongia excavata*. The adaptive significance in this case is more obscure, for the cylindrical forms occur side by side with the others.

The Permian calcisponge *Guadalupia* shows a more striking example of variability in growth form, which may be occasioned by the degree of water movement. This sponge is common in the patch-reef lenses of the Leonardian and Guadalupian of west Texas. At a single locality, and often in a single block of limestone, the growth form can be seen to vary from a stipitate, cup-shaped form to explanate sheets on the one hand, and to intricately branched, ramose forms on the other. These forms may have occupied different positions on the patch reef, though in the available collections it is not possible to demonstrate such localization. It is possible that the more explanate forms were localized on the exposed parts of the reef where a constricted osculum was not necessary and where a flattened shape minimized damage by the surf. The deeper cup-shaped forms may have lived in sheltered spots in hollows of the reef or on its flanks, where concentration of the outgoing current from the sponge was desirable. The ramose forms may have occupied the quieter waters also, for similar variations have been noted in reef corals (see Vaughan and Wells, 1943) in which individuals of a single species living in quiet water assume a ramose form, while those on the exposed parts of the reef are massive or flattened. Many of the ramose individuals of *Guadalupia*, however, have the branches oriented in a single direction which suggests the effects of a prevailing water current. Illustrations of these forms of *Guadalupia* are reserved for a subsequent paper on the calcareous sponges, but the basic cup-shaped form is illustrated incidentally on plate 22, figures 6 and 7.

The lower Leonardian hexactinellid *Pileolites baccatus* shows a high degree of variability in individual growth form at the same locality, which is difficult to relate to conditions in the surrounding water. This sponge grew by adding successive horizontal layers of spicules to a flat base so that the sides are nearly perpendicular. The shape of the initial base, however, varies from a narrow elongate form, through wider equidimensional shapes, to very wide and frequently elongate ones. In this case it would seem that the sponge grew initially in a lateral direction, as a flat sheet, until it was limited, possibly by contact with other organisms on the sea floor, after which it continued its growth only in an upward direction. These variations in form are illustrated on plate 50, figures 1–3 and 6–12. All but figures 1 and 2 represent sponges from a single small block of limestone.

Ontogenetic variation is well shown by individuals of the hexactinellid *Microstaura doliolum.* Both at U.S.N.M. 703c (see pl. 34, figs. 2, 3, 6, and 8) and at A.M.N.H. 675 (see pl. 34, figs. 10–12) numerous specimens of various sizes are available from essentially a single spot in a single bed. It can be seen that the smallest juvenile forms are nearly spherical, and that as the sponge grew it became more elongate vertically, passing through a barrel-shaped stage to an elongate cylindrical form. The largest specimens show an incipient development of prismatic sides. Were these sponges known only from single examples at different localities, they might have been assigned to separate species. There can be little doubt from the fact of their occurrence together, and their obvious relatedness in terms of their spicule size and arrangement, that they represent growth stages of a single species.

That ontogeny need not, on the other hand, involve changes in shape is illustrated by the hexactinellid *Stioderma coscinum.* The small specimen illustrated on plate 47, figures 4–6, has essentially the same form as the very large one shown on figure 1 of the same plate. The characteristic inrolled oscular lip is also present both on the small form and on fragments of much larger individuals, such as that seen on plate 48, figures 3 and 5.

All the cases of individual variation cited above should serve as a warning to the taxonomist to treat with extreme caution differences in external shape that are not accompanied by differences in the spicular net or in the organization of the pores and canals.

TAXONOMIC CHARACTERS

Fossil siliceous sponges present a wide variety of morphological features ranging from the minutest details of individual spicules to the gross form and architecture of the whole body. Fortunately for the systematist who works with fossil material, the classifications established for Recent sponges are based largely on such skeletal features. The main differences between paleontological and zoological classifications are occasioned by the loss of the microscleres in most fossil material. These are significant chiefly at the ordinal level. The manner of union of the megascleres has generally been substituted for the form of the microscleres in paleontological classifications.

The two classes of siliceous sponges are separated on the fundamental symmetry of the megascleres. At the ordinal level the principal taxonomic characters are the basic form of the megascleres, their manner of union in the skeletal net, and, in the demosponges, the degree to which the skeletal net is differentiated into specialized parts. Characters significant at the family level are the geometric arrangement of the spicules in the skeletal net, the principal types of megascleres present, the general architecture of the sponge body, and the fundamental arrangement of the canal system. Genera can be recognized by the basic shape of the body, the pattern of distribution of the pores and canals, the presence of particular kinds of specialized spicules, and the details of the construction of the skeletal net. Species are separated on more quantitative characters, such as the dimensions and relative proportions of individual spicules, canals, and pores, as well as on the growth form, or range of growth form, of the body as a whole. At the specific and generic levels the range of variation in characters is important, particularly because the sponges are sessile animals with a low level of body integration and are therefore readily modified by environmental conditions.

The most serious difficulty in the study of fossil sponges is the fragmental nature of much of the material. Isolated spicules can generally be identified as to class and frequently as to order. It is usually impossible to identify them further, except in the rare cases of highly specialized spicules characteristic of a particular genus. Families are diagnosed by combinations of spicule types rather than by single types. Isolated spicules are useless at the species level. If a fragmental specimen preserves a coherent portion of the skeletal net, it is frequently possible to assign it to a family, but rarely to a lower category. Generic and specific identification require the presence of a considerable portion of the whole individual, so that the general body form and the pattern of the pores and canals can be ascertained. Species belonging to more specialized and highly organized groups can usually be identified with more meager material than those that belong to relatively simple and generalized groups.

In the present study every effort has been made to take into account the range of individual variation in establishing the limits of species. In the absence of strong indications to the contrary, obviously related individuals from the same locality have been assumed to be conspecific.

GLOSSARY OF MORPHOLOGICAL TERMS

The section on Porifera of the "Treatise on invertebrate paleontology" contains a reasonably complete glossary of morphological terms (De Laubenfels, 1955, pp. E28–E31), and the terminology used in the present paper conforms in large part to it. Certain terms not included in that list are defined below, along with others that the writer has preferred to define somewhat differently, in accordance with the usage of other students of fossil sponges.

Body Wall: That part of a sponge between the outer surface and the spongocoel, or principal internal cavity.

Chiastoclone: A desma consisting of a short shaft bearing three equal clads at each end.

Choanosome: That part of a syconoid or leuconoid sponge in which the canals and flagellated chambers are located; essentially all of the sponge internal to the dermal layer or ectosome.

Choanosome Spicules: The spicules of the choanosome; equivalent to the interior spicules, plus the gastralia, if any.

Clavule: Any monaxon bearing an elaborate enlargement at one end; it is not necessarily an umbel, as stated by De Laubenfels (1955, p. E28).

Cleme: A monaxon with broad-based, recurved, hook-like projections along its length, which are commonly in alternating position. Contrary to De Laubenfels' statement (1955, p. E28) it is not the same as an uncinate, at least as De Laubenfels defines the latter term (1955, p. E31).

Comitalia: Small spicules adjacent and parallel to larger spicules of a different kind.

Dermalia: Differentiated spicules covering, or subjacent to, the outer surface of a sponge; those spicules of the ectosome, other than prostalia, which are different from the interior spicules.

Dermal Ray: The tangential ray of a dermal hexact, pentact, or stauract (see tangential ray).

Dermal Surface: The exterior surface of a sponge.

Dendroclone: A tetraxonic desma with a long, smooth shaft bearing a short, triclad, arborescent cladome at one end and a terminal arborescence of equal size at the other end.

Dicranoclone: A tetraxonic desma consisting of one short distal ray and three longer proximal rays of equal length.

Distal Ray: The ray of a dermal, or gastral, hexact or pentact, which is directed away from the body wall; the ray of a dicranoclone which is directed towards the outer surface of the body.

Ectosome: The specialized outer layer of a sponge.

Ectosome Spicules: The spicules of the ectosome.

Furcula (New Term): A spicule shaped like the bone of the same name in birds ("wishbone" or "merrythought").

Gastralia: Differentiated spicules lining the cloaca.

Gastral Surface: The surface of the cloaca.

Interior Spicules: All those spicules occurring within the body wall of a sponge between the dermal and gastral layers (equals the parenchymalia of some authors).

Main Skeleton: Those spicules that form the chief support of the body wall of a sponge, exclusive of dermalia, gastralia, and prostalia (equals principalia of some authors).

Prostalia: Spicules, other than dermalia, projecting from the outer surface of a sponge. Prostalia projecting from the base of a sponge, and forming a root tuft, are called basalia.

Proximal Ray: The ray of a dermal, or gastral, hexact or pentact, which is directed towards the interior of the body wall; the rays of a dicranoclone directed towards the interior of the sponge.

RHIZOCLONE: A monaxonic desma bearing lateral arborescences along its whole length.

SPHAEROCLONE: A desma consisting of a central spherical body from one side of which more than three rays extend.

SYNAPTICULA: A short bar of secondary silica connecting adjacent spicules in certain hexactinellids.

TANGENTIAL RAY: One of the rays of a hexact, pentact, stauract, or triact, which lies in the plane parallel to the dermal or gastral surface of the sponge.

TETRACLONE: A textraxonic desma consisting of four rays of nearly equal length, each bearing a terminal arborescence; one ray may be longer than the others.

UMBEL: A monaxon with an umbrella-shaped expansion at one end, usually formed by multiple, partly fused, recurved clads; a type of clavule.

SYSTEMATIC PALEONTOLOGY

THE FOLLOWING PAGES present descriptions of all the species and higher taxa of siliceous sponges that are known from the rocks of Desmoinesian to Guadalupian age in the area between eastern Kansas in the United States and southern Coahuila, Mexico. All holotypes and figured specimens of previously described species have been examined by the writer. The most extensive collections studied were from the upper Missourian of southern Kansas and northern Oklahoma, from the Missourian and lower Virgilian of north central Texas, from the middle Missourian and Permian of trans-Pecos Texas, and from the Permian of southeastern New Mexico.

The phylogenetic relationships of each taxon have been discussed wherever feasible. Where specific paleoecological or physiological inferences could be made from the specimens at hand, they are discussed under the heading Biological Observations in the section on the particular species. In the sections on the occurrences of each species, the inferred environments in which they lived are listed under the heading Biotopes. These have been defined in terms of the faunal or sedimentary facies. In most cases these terms are the same as those used in the classification of faunal facies given in the introductory part of this paper, but in some cases a more specific designation is given. Under the heading Lithotopes the inferred sedimentary environments are listed in terms of the general lithology of the enclosing sediments. A more precise definition of sedimentary environments is beyond the scope of this paper, but discussions of particular lithotopes are given incidentally in the section on Faunal Facies in the introductory part of this paper.

PHYLUM PORIFERA GRANT, 1836

CLASS DEMOSPONGEA SOLLAS, 1875

DIAGNOSIS: Sponges with rhagon architecture and small flagellated chambers; choanocytes relatively small; protoplasm not syncytial and with much mesoglea; skeleton, when present, of spongin alone, of spongin with sand particles, or of spongin with siliceous spicules, the principal megascleres being either monaxonic or tetraxonic, or both.

DISCUSSION: The chief characters that have been used in separating the orders of this class are: (1) the presence or absence of spicules, (2) the types of principal spicules, both megascleres and microscleres, and (3) the over-all form of the skeletal architecture and the degree of differentiation of its parts, Students of Recent demosponges have differed widely in the establishment of the major subdivisions of this group. Some writers (e.g.. Dendy, 1921) have emphasized the basic form of the microscleres, whereas others (e.g., De Laubenfels, 1936) have emphasized the degree of differentiation of the megascleres and the general architecture of the sponge. The older subdivision of the spicule-bearing demosponges on the basis of the presence or absence of tetraxonic megascleres (Tetractinellida versus Monactinellida) has generally been abandoned.

ORDER **EPIPOLASIDA** SOLLAS, 1888

DIAGNOSIS: Megascleres exclusively monaxonic, but tylostyles absent; architecture commonly radiate; cortex or dermal specialization commonly present; spongin absent.

DISCUSSION: The relation of this order to the other orders of demosponges, which are characterized by exclusively monaxonic megascleres, is discussed below under the family Heliospongiidae.

HELIOSPONGIIDAE FINKS, NEW FAMILY

DIAGNOSIS: Skeleton very regularly organized into upwardly divergent ascending tracts connected by upwardly convex layers of horizontal tracts; each tract is a bundle of parallel, smooth oxeas of one kind, possibly cemented together by secondary silica; a thin dermal layer of tangentially disposed oxeas, with secondary siliceous cement, may be present; canal system well developed, with prosochetes parallel to ascending tracts and apochetes parallel to horizontal tracts; whole sponge commonly tubular and branching, with well-developed cloacas; no root tuft.

DISCUSSION: The three genera of this family are separated chiefly on the basis of general form and the presence or absence of a dermal layer. Because of the relatively poor preservation of the original material of *Heliospongia*, the true nature of its spicules were not recognized by Girty when he established the genus. Girty (1908, p. 288) interpreted the spicule tracts as the rays of single spicules and concluded that the spicules were hexacts. R. H. King at first followed Girty in this respect (1933, p. 84) but subsequently interpreted the spicules as tetracts (1943, p. 7). When the writer first commenced the present study, he was disposed to agree with King's later interpretation. Having at that time no idea that the spicule tracts were anything but the rays of individual spicules, the writer concluded that the spicules could not be hexacts, because nowhere in the skeletal net could junctions of three rays at right angles be found. An interpretation of the spicules as tetraxonic was, however, not inconsistent with the observed geometry of the net. Subsequently, several excellently preserved silicified specimens of *Heliospongia excavata* came to hand, in which the presumed spicule rays were clearly seen to be bundles of parallel oxeas. These specimens are illustrated on plate 2, figures 5, 6, 8, and 12. Girty's original thin sections of the type material of the genotype, *H. ramosa*, were then reëxamined, and it soon became apparent that, when one knew what to look for, the same oxeas were clearly visible. Photographs of these sections are reproduced here on plate 3, figures 2–4. The type material is completely calcified. The individual oxeas have since been seen on a great many unsectioned specimens of all three species of *Heliospongia*, in both calcified and silicified material. No axial canals are visible on the calcified type material. However, several oxeas were isolated from a silicified specimen of *H. excavata* which show well-developed axial canals (see pl. 3, fig. 1). Because axial canals are well developed only in the spicules of siliceous sponges, having never been clearly observed in the spicules of the calcisponges (see Minchin, 1910), there seems to be little doubt that *Heliospongia* is a siliceous sponge. There are no indications here of hexacts or of the triaxonic symmetry of the skeletal net present even in those hexactinellids composed only of monaxons, so we must conclude that *Heliospongia* is a demosponge. The organization of monaxons in parallel bundles, or spicule tracts, is a common structural plan in the demosponges, and nothing in the anatomy of *Heliospongia* negates its assignment to this class.

Girty (1908, p. 287) recognized the similarity of *Coelocladia* to *Heliospongia* in gross morphology but stressed the differences between the two genera, and considered the former to be a lithistid sponge. Although, as Girty stated, the skeletal net of *Coelocladia* does not show so clearly the radial and longitudinal elements so characteristic of *Heliospongia*, a comparison of a longitudinal section of one of Girty's paratypes of *Coelocladia* (pl. 6, fig. 5) with a corresponding section of *Heliospongia* (pl. 2, fig. 9) will amply demonstrate the essential identity of structural plan. No spicules could be seen in the thin sections of Girty's original material of *Coelocladia*. However, a thin section of a specimen from U.S.N.M. 518i, which is conspecific with the type, shows oxeas essentially identical to those of *Heliospongia*, and it seems therefore likely that the two genera are related. This section is illustrated on plate 7, figure 10. *Coelocladia* differs from *Heliospongia* not only in the smaller size and less regular disposition of its spicule tracts, but also in its possession of an imperforate dermal layer which is, at least in the sole species now recognized, prolonged as tubular collars about the large prosopores. No spicules have been observed in the new genus *Coelocladiella*, and it is here tentatively considered to be related to *Coelocladia* and *Heliospongia* only on the basis of its gross morphology and the form of the skeletal net.

Because these sponges have a spicular structure almost unique among fossil sponges, as well as a common gross morphology, there is little doubt that they should be recognized as a new family. It is difficult to place this family unequivocally in one of the presently recognized orders of the demosponges. The most recent complete revision of the class, that of De Laubenfels (1936), recognized five orders characterized by exclusively monaxonic megascleres. These are (1) Haplosclerida Topsent, (2) Poecilosclerida Topsent, (3) Halichondrida Vosmaer, (4) Hadromerida Topsent, and (5) Epipolasida Sollas. The first two orders are distinguished from the last three by the absence of a specialized dermal skeleton, the first differing from the second in that only one kind of megasclere is present in a given species. The third order is characterized by the presence of some sort of dermal specialization and by the fact that the spicules are more often grouped into tracts or bundles; the simpler members of this group, for example, the family Halichondriidae Gray, may have as uniform a spiculation as that seen in the Haplosclerida but differ in the possession of the ordinal characters. The fourth and fifth orders are both characterized by the strong development of a cortex, by radiate architecture of the skeleton, by the almost total absence of spongin, and by the presence of astrose microscleres. The first of these differs from the second in that the megascleres are exclusively tylostyles. The known Heliospongiidae have an extremely uniform spiculation, such as characterizes the simplest order, the Haplosclerida. However, a distinct dermal layer is present, especially well developed in *Coelocladia*. This character, together with the presence of a radiate architecture and the probable absence of spongin in the very dense skeleton of spicule tracts, makes the Epipolasida the best repository for the family. No microscleres are known from the heliospongiids. Unfortunately the phylogenetic significance of the presently recognized orders of demosponges is open to considerable doubt, and the present classification is best considered as a matter of convenience. Many authors believe the Epipolasida, in particular, to be polyphyletic, and to have been derived, at least in part, by loss of tetraxons from sponges like those in the Order Choristida Sollas. The heliospongiids, however, are at least as ancient as any of the known choristids and may well be primitively exclusively monaxonic. The skeletal architecture of the heliospongiids shows considerable resemblance to that of the contemporary Haplistiidae, described below, but in the latter family the spicules are chiefly rhizoclones.

De Laubenfels (1955, p. E64) placed *Heliospongia* and *Coelocladia* in the anomocladine lithistid family Cylindrophymatidae Schrammen, apparently on the basis of their external resemblance to *Cylindrophyma*. The spicules and the skeletal structure of these sponges are, of course, by no means those of an anomocladine lithistid.

The Cretaceous sponge *Pharetrospongia* Sollas, 1877, deserves mention here, for its skeletal net is similarly composed exclusively of bundles of parallel simple oxeas. This is the only other fossil sponge known to the writer with such a skeletal construction. The original illustrations of its spicules are reproduced here on plate 2, figures 7, 10 and 11. De Laubenfels (1955, p. E98) established for this sponge the family Pharetrospongiidae, which he included among the pharetronid calcisponges. Although the original specimens were calcified, this sponge may well have been a demosponge and originally of siliceous composition. Most of the specimens of *Heliospongia* and *Coelocladia* from the limy Pennsylvanian shales are quite calcified, although these sponges were surely originally siliceous. *Pharetrospongia* tends to assume frondose and funnel-shaped forms reminiscent of *Coelocladia*, but the forms of the pores are different, those of the incurrent surface apparently being polygonal and closely spaced, and those of the excurrent surface being circular and widely spaced (see pl. 7, figs. 1–3).

The chief evidence that the heliospongiids were silicisponges is cited above, namely, that the spicules possess well-developed axial canals. An additional indication of the originally siliceous nature of the skeleton is the fact that the presently siliceous specimens preserve the individual spicules most clearly and in the finest detail, whereas the calcareous specimens are coarsely recrystallized and their spicules are more obscure (see pl. 3, figs. 2–4). The spicules are so closely crowded in the tracts that it is probable that these sponges were quite stony in the living state, as is the case with many epipolasid sponges in modern seas. The frequent occurrence of quite large encrusting and epoecious organisms, such as brachiopods, Bryozoa, and corals, on many specimens, tends to support this conclusion. The flesh of these sponges must have formed a quite thin covering over the mineral skeleton, as is also the case with many modern epipolasid sponges.

All the members of this family grew by adding horizontal tract layers to the upper ends of the branches, the top surface consisting of the last-formed layer. These layers are more or less tangent to the sides of the sponge, and the sponge could not increase in diameter except by upward expansion.

INCLUDED GENERA: *Heliospongia* Girty, 1908 (Missourian–lower Leonardian); *Coelocladia* Girty, 1908 (upper Desmoinesian–Virgilian); possibly *Coelocladiella*, new species (Missourian–Wolfcampian).

OCCURRENCE: Pennsylvanian, Permian; south central United States; possibly the Permian of Tunisia.

GENUS **HELIOSPONGIA** GIRTY, 1908

Heliospongia GIRTY, 1908, p. 288.

DIAGNOSIS: Large, cylindrical to flabellate, branching sponge, with thick body wall and relatively narrow cloaca; skeletal net relatively dense and tracts thick; horizontal tract layers strongly downturned about periphery; dermal layer essentially absent; large prosopores frequently stellate; large apopores circular, approximately as large as the prosopores and commonly arranged in vertical and horizontal rows.

DISCUSSION: The characters used to separate the species in this genus are: (1) total size, (2) growth form, (3) ratio of cloaca diameter to sponge diameter, (4) depth and position of cloacae, and (5) the spacing of the spicule tracts. Although each of the three recognized species can be characterized by a specific combination of these features, there is considerable overlapping in the range of variation of each of the characters between the type populations. Furthermore, in some populations outside the type locality, the same characters may occur in different combinations. It seems probable, therefore, that the fossil populations assigned to this genus represent a single lineage, continuously occupying the same area and general environment, and undergoing both a continuous phyletic evolution (in the sense of Simpson, 1944, 1953) as well as a geographic differentiation of local populations. The discrimination of species in such a series of descendent populations must of necessity be arbitrary. The writer prefers to retain the three previously named species and characterize the variant populations with reference to them.

The genus is known with certainty only from Pennsylvanian and Permian beds in the south central part of the United States from Missouri to west Texas. It first appears in the lower Missourian rocks of north central Texas, and the last representatives occur in the middle Leonardian rocks of west Texas. Its widest known distribution is in middle and upper Missourian rocks, where it has been collected from many localities between western Missouri and the Glass Mountains of west Texas. This probably reflects its actual distribution throughout most of the time interval from lower Missourian through Virgilian. It is known from Permian beds only in the west Texas area, which probably more or less reflects its actual distribution at this time, for the open shelf seas, to which it appears to be confined, retreated from the more northerly and easterly regions during the Permian.

The five specific characters listed above show changes with time. Total size tends to increase; growth form changes from flabellate to cylindrical; the cloaca tends to increase in diameter relative to that of the sponge; short, laterally placed cloacae give way to a single axial cloaca; and the spacing of the spicule tracts tends to decrease. For each of these characters, contemporaneous local populations may be at different stages of development, and, with the exception of tract spacing, the changes are relatively localized in time. The earliest stage in all the characters is represented by the populations from the lower and middle Missourian of north central Texas (Palo Pinto and Graford formations) which include the type population of *H. excavata*. These forms have relatively narrow, frequently flabellate, branches; short, relatively narrow cloacae, which are placed laterally as well as terminally, so that the axial region of the sponge is commonly solid; and a relatively wide spacing of spicule tracts. Contemporaneous middle Missourian populations from the Glass Mountains (Gaptank formation, bed 10) lack the flabellate form and lateral cloacae and show a somewhat closer spacing of spicule tracts. A contemporaneous middle Missourian population from Kansas City, Missouri (Frisbie limestone member of the Wyandotte formation), also shows a closer tract spacing, but otherwise resembles the forms from north central Texas.

In the upper Missourian rocks of eastern Kansas (Stanton and Plattsburg limestones and adjacent shales), which include the type population of *H. ramosa*, the sponges are entirely cylindrical and ramose, although of the same general diameter; there is a single axial cloaca which is relatively wider in relation to the diameter of the sponge; and the average spacing of the tracts is closer than in the earlier forms. The sponges from the contemporaneous beds of north central Texas (Caddo Creek formation) may be essentially the same; they were not examined by the writer, but R. H. King (1938) reports *H. ramosa* from these beds. No Virgilian occurrences are known. The next occurrences available are in the "*Uddenites*-zone" of the Gaptank formation and in the overlying Wolfcamp formation of the Glass Mountains. These are both probably lower Permian. Here there occur forms which are essentially the same as those from the upper Missourian beds, except that some individuals have a considerably larger over-all size. Associated with them are forms that have a distinctly closer tract spacing and are indistinguishable from the sponges found in the overlying Leonardian beds. The Leonardian populations, which are known from the shelf and patch-reef facies of the Leonard formation in the Glass Mountains and from similar facies of the Bone Spring formation in the Sierra Diablo, are all of larger diameter than the Pennsylvanian forms and uniformly possess a close spacing of the spicule tracts. These occurrences include the type population of *H. vokesi*.

The evolutionary developments may be summarized as follows: (1) Sponge diameter did not increase significantly until the lower Permian. The populations from the Wolfcamp formation contain both large and small individuals. Those from the succeeding Leonardian beds are nearly all large. (2) The flabellate shape disappeared at the end of the middle Missourian, but the populations in the Glass Mountains apparently lost it before this time. (3) The higher cloacal ratio became fixed by upper Missourian time. The earlier populations generally have a lower ratio but show considerable variation both between and within populations. In an apparent reversal of the over-all trend, the lower Missourian sponges in central Texas have a higher ratio than those from the middle Missourian in the same area. (4) The predominance of short lateral cloacae over deep axial cloacae seems to be confined to the lower and middle Missourian populations from central Texas. (5) Tract spacing is greatest in the lower Missourian sponges from central Texas and shows a significant decrease in the otherwise similar middle Missourian sponges of the same area. Middle Missourian populations from other areas show a slightly closer spacing, with a further slight reduction evident in the upper Missourian forms. The Wolfcampian populations include forms with tract spacing similar to that of the upper Missourian sponges as well as individuals with considerably closer spacing. This closest spacing of tracts becomes general in the populations of the Leonardian beds.

Each of these developments seems to have taken place independently. The presence of lateral cloacae is to some extent correlated with the flabellate shape of the sponge, but, within a single population, individual sponges may have a cylindrical shape and yet have lateral cloacae and a solid axial region, while others may have a flabellate shape but have an axial cloaca and no lateral ones. The size of the principal prosopores and apopores, and their associated canals, has not been included here as a diagnostic specific character because they are closely correlated with the diameter of the sponge; they are notably independent of the spacing of the spicule tracts.

In general, the evolutionary history of this genus may be divided into three main stages: (1) lower to middle Missourian, (2) upper Missourian to Wolfcampian, and (3) Wolfcampian to Leonardian. In the first stage the flabellate shape was dominant, with narrow cloacae that were mostly laterally placed. Considerable geographic, as well as individual, variation prevailed in these features. The only consistent trend during this stage was towards a reduction in tract spacing, but this, too, was subject to local variation. In the second stage the cylindrical form, single axial cloaca, and relatively large cloacal ratio became stabilized. Tract spacing was likewise maintained but at a slightly lower value than in the earlier forms. In the third stage the diameter of the sponge increased, and, apparently independently of this development, the tract spacing was further reduced. Both these new developments became general in the latest populations. The three named species can be defined so as to correspond to these stages, *excavata* corresponding to the first, *ramosa* to the second, and *vokesi* to the third. At the type localities of each of these, there is little difficulty in identifying a reasonably complete specimen. At other localities and horizons, however, the intermediate nature of the populations often makes an arbitrary assignment necessary. In these cases the spacing of the spicule tracts seems to be the most useful single diagnostic character. This feature shows the most consistent trend with time and has the further advantage of being applicable to fragmental specimens. The lower and middle Missourian specimens, corresponding to *excavata*, in general have a vertical spacing of the spicule tracts greater than 1.0 mm.; the upper Missourian to Wolfcampian specimens, corresponding to *ramosa*, have a vertical spacing of about 1.0 mm.; and the Wolfcampian to Leonardian specimens, corresponding to *vokesi*, have a vertical spacing of less than 1.0 mm. The use of such an arbitrary criterion undoubtedly does violence to the biological unity of some of the intermediate populations. In the Wolfcampian populations *ramosa* will have to be recognized, in some localities, along with *vokesi*, although they may actually be only individual variants in a single biological population. In this case, however, there is no better way out for some of the intermediate forms, for the only known criteria for separating the two species are tract spacing and sponge diameter; in those forms that have the tract spacing of one species and the diameter of the other, any choice must be arbitrary.

Heliospongia appears to have been confined throughout its history to the shallow shelf seas. The absence of the genus from upper Leonardian and later beds may be due to lack of a suitable environment. It is confined during the lower and middle Leonardian to the shelf facies and patch-reef facies beds of the Leonard formation (especially Hess facies) in the Glass Mountains and in the patch-reef and back-reef facies of the lower Bone Spring in the Sierra Diablo. It is absent, however, from the shelf-facies beds of the upper Leonardian Victorio Peak limestone. Termier and Termier (1955) report some sponges from Permian beds (probably Leonardian) in Tunisia which may be *H. vokesi*, though they were not identified as such (see below). The associated fauna suggests a shelf or patch-reef biotope.

GENOTYPE: *Heliospongia ramosa* Girty, 1908. This species was specifically designated by Girty in his original paper, contrary to the statement made by De Laubenfels (1955, p. E64) that it was subsequently designated by King in 1943.

INCLUDED SPECIES: *Heliospongia ramosa* Girty, 1908 (upper Missourian–Wolfcampian); *H. excavata* R. H. King, 1933 (lower Missourian–middle Missourian); *H. vokesi* R. H. King, 1943 (Wolfcampian–lower Leonardian).

OCCURRENCE: Lower Missourian–lower Leonardian (south central United States); Leonardian (Tunisia).

Heliospongia excavata R. H. King, 1933

Plate 1, figures 1–6; plate 2, figures 1, 2, 5–8, 12; plate 3, figure 1

H. excavata R. H. KING, 1933, p. 85, pl. 8, fig. 8.
H. ramosa Girty, R. H. KING, 1933, p. 84, pl. 8, fig. 6.

DIAGNOSIS: Form of sponge commonly flabellate, but also digitate with slender, cylindrical branches; cloacae multiple, very narrow and short, opening on sides as well as at upper end, and absent from axial region except near termini of branches; skeletal net more open than in *ramosa* or *vokesi*, with horizontal layers spaced more than 1.0 mm. apart and ascending tracts spaced approximately 0.9 mm. apart.

DESCRIPTION: The branches of this sponge are most often laterally compressed, and expand upward into flabellate fronds. Some branches may be essentially cylindrical, and the flabellate fronds may diverge upward into separate cylindrical portions. The fronds may anastomose laterally. Diameters of cylindrical stocks are 12–45 mm. (mostly 20–25 mm.). The flabellate fronds have the same thickness as the single cylinders but attain widths up to 90 mm. The largest individual sponge (see pl. 1, fig. 3) is 295 mm. high and 202 mm. in maximum width. The basal part of this sponge is missing, but is very nearly a complete individual. A single axial cloaca is generally present at the tip of the cylindrical fronds, and similar cloacae are present on the upper edges of the flabellate fronds. These cloacae are generally not very deep, so that the axial portion of the lower part of the sponge is solid. Similar cloacae open on the sides of most of the specimens and extend obliquely downward only a few millimeters into the sponge. Both types of cloacae are 2–7 mm. in diameter, but the lateral ones narrow downward quite rapidly. The ratio of axial cloaca diameter to sponge diameter in the cylindrical branches ranges from 1:4 to 1:9. The exterior surface bears circular prosopores 0.2–1.0 mm. in diameter. Those of larger size are rather regularly spaced 2–5 mm. apart; they often have a stellate appearance because of short surface grooves, less than 0.5 mm. wide, which converge on them. Circular apopores, 0.4–1.3 mm. in diameter, open into the cloacae; they are spaced 1–2 mm. apart and tend to be aligned in vertical rows. The prosochetes run inward and downward parallel to the ascending tracts. The apochetes which empty into the axial cloacae seem to follow the horizontal tracts upward and inward, but at least some of those emptying into the lateral cloacae follow the ascending tracts. Unlike the other species of *Heliospongia*, the ascending tracts do not always radiate upward and outward from the axis of the sponge, even in cylindrical branches. Centers of radiation may develop lateral to the axis at various levels of the sponge. As a result, the horizontal layers, which are perpendicular to the ascending tracts, may show a double, instead of a single, upwardly arching form in longitudinal section (see pl. 2, fig. 1). Tract diameters are 0.15–0.50 mm. (mostly 0.3 mm.); the horizontal tract layers are spaced 1.2–2.4 mm. (mostly 1.2 mm.) apart, and the ascending tracts are spaced 0.6–1.2 mm. (mostly 0.9 mm.) apart. As the ascending tracts diverge upward, new ones are added by intercalation. The tracts expand at their junctions with one another, so that the spaces they outline are elliptical to circular. The outer surface is covered with a thin tangential layer of tracts, flattened in the dermal plane and outlining the circular dermal pores. This layer is confluent with the down-bent peripheral portions of the horizontal tract layers. The tracts are bundles of parallel oxeas 0.24–0.50 mm. long and 0.024–0.036 mm. thick. Most are slightly curved, those outlining the circular dermal pores distinctly so. In well-preserved spicules (see pl. 3, fig. 1) an axial canal is present, occuping about one-fifth of the diameter of the spicule. The best-preserved spicules known from this genus have been obtained from silicified specimens of the present species.

Biological Observations: The initial attachment and juvenile stage have been observed in only one specimen, a bun-shaped mass, 17 mm. in diameter and 6 mm. high, which is attached to the inner surface of a funnel-shaped individual of *Coelocladia spinosa* (see pl. 4, fig. 2). No cloaca is present, and the tracts are rather irregularly arranged. It bears pores 0.3–0.4 mm. in diameter; the tracts are 0.2–0.3 mm. thick and are composed of curved oxeas 0.4 mm. long and 0.03 mm. thick.

Discussion: The foregoing description is based on specimens from the type locality, the Brownwood shale member of the Graford formation (middle Missourian) in the vicinity of Bridgeport, Texas, as well as on essentially identical material from the overlying Rock Hill limestone member of the Graford formation at the same locality. R. H. King (1933, p. 84) reported *H. ramosa* from this same locality on the basis of cylindrical fragments that lacked lateral cloacae. In the present writer's opinion, all *Heliospongia* from this locality should be referred to *excavata*, for branches of the same description can be seen to be parts of sponges having generally the typical flabellate form and lateral cloacae of that species. Even fragmentary cylindrical specimens can be identified as belonging to *excavata* on the basis of the wider spacing of the horizontal tract layers, for this feature is present at the type locality even when the diagnostic features of gross morphology are lacking. The earliest known population of *Heliospongia*, that from the lower Missourian Palo Pinto limestone at Salesville, Texas, in the same region, has the essential characters of *excavata*. However, the cloacal ratio is somewhat greater, ranging from 1:3 to 1:4, and the spacing of the horizontal tract layers is also greater, being mostly 1.5 mm. Two populations contemporaneous with typical *excavata* also differ in certain respects. That from bed 10 of the Gaptank formation in the Glass Mountains consists entirely of cylindrical fragments with only axial cloacae. The largest specimen, however, consists of two parallel and laterally fused cylinders, and approaches the subflabellate form of some typical *excavata;* it has no lateral cloacae. The horizontal tract layers of the specimens from this locality are more closely spaced than those of typical *excavata* (range 0.6–1.8 mm.), but they are more widely spaced than in *H. ramosa*. The cloacal ratios fall in the same range as those of typical *excavata* (1:4–1:7). The few specimens available from the Frisbie limestone member of the Wyandotte formation at Kansas City have a similar horizontal tract spacing, but most of the fragments have a flabellate form. The cloacal ratio is higher than in either the Gaptank specimens or in typical *excavata*, ranging from 1:3 to 1:5. Of these three variant populations the population from the Palo Pinto limestone is closest to typical *excavata* and is here assigned to that species. The two middle Missourian populations show greater differences from the type population, but the evolutionary stage represented by their tract spacing seems to be earlier than that of *H. ramosa*. Because of this, and also because of their contemporaneity with typical *excavata*, they are tentatively assigned to that species.

MATERIAL: About 100 calcified large fragments from the type locality, including the holotype, were available for study. The overlying Rock Hill limestone yielded two fragments and a large, nearly complete individual, all of which were silicified and prepared with acid. The large individual is the most complete specimen of this species known to the writer (see pl. 1, fig. 3). Four silicified and acid-prepared fragments are known from the Palo Pinto limestone. The Gaptank formation yielded 13 calcified fragments, and the Frisbie limestone five calcified fragments.

OCCURRENCE: *Horizons:* Lower and middle Missourian. *Localities:* U.S.N.M. 510c, 518f, 518g, 700; Wyandotte formation (Frisbie member) quarry at 33d and Roanoke, Kansas City, Missouri. *Biotope:* Pennsylvanian shelf facies. *Lithotopes:* Calcareous shales and argillaceous limestones.

TYPES: Holotype, B.E.G. No. 11730; hypotypes, B.E.G. No. 11731, U.S.N.M. Nos. 127579, 127580, 127581, 127582, 127584.

Heliospongia ramosa Girty, 1908

Plate 2, figure 3; plate 3, figures 2–4

Heliospongia ramosa GIRTY, 1908, pp. 289–290, pl. 16, figs. 8, 9, pl. 17.

H. ramosa var. *parallela* GIRTY, 1908, p. 290, pl. 16, fig. 10, pl. 18.

Not *H. ramosa* Girty, R. H. KING, 1933, p. 84, pl. 8, fig. 6.

? *Stylopegma conica* R. H. KING, 1943, p. 20, pl. 2, fig. 2.

DIAGNOSIS: Form of sponge digitate, with slender, cylindrical, subparallel branches, each with a deep, relatively narrow, central cloaca opening terminally; horizontal layers spaced approximately 1.0 mm. apart, and ascending tracts spaced approximately 0.6 mm. apart.

DESCRIPTION: This species consists of long, thin, cylindrical tubes, which branch repeatedly, and rather openly, often at right angles. Frequently several closely spaced parallel branches arise from a single parent stem. Adjacent branches in some instances fuse near their upper ends. The whole sponge may be more than 200 mm. high. The branches are 8–23 mm. in diameter, and each branch has a deep axial cloaca 2–7 mm. in diameter. Lateral cloacae are never present. The cloacal ratio ranges from 1:2 to 1:5. The ascending tracts radiate regularly from the axis of the sponge. The horizontal tract layers are spaced 0.9–1.2 mm. (mostly 0.9 mm.) apart, and the ascending tracts are spaced 0.4–0.8 mm. (mostly 0.6 mm.) apart. The tracts are 0.2–0.4 mm. in diameter. The individual oxeas are 0.24–0.50 mm. long and 0.010–0.037 mm. thick. The large prosopores are 0.5–0.9 mm. (mostly 0.6 mm.) in diameter and are spaced 2–3 mm. apart. The intervening surface bears more closely spaced smaller pores, down to 0.2 mm. in diameter. The apopores on the cloacal surface are mostly about 1.0 mm. in diameter.

DISCUSSION: Parallel branches arising along the length of a single basal stock may give sponges of this species an over-all flabellate form, but unlike *H. excavata* the individual branches maintain their identity. The foregoing description is based on the type material, but collections from other upper Missourian beds in the same region of southeastern Kansas are essentially identical. Some specimens from U.S.N.M. 518p show a greater spacing of the horizontal tracts, falling within the range of typical *H. excavata.* They show no other features of *excavata*, however. These specimens represent the upper extreme of horizontal-tract spacing in *ramosa* (some as much as 1.8 mm.), but they are well short of the upper limit shown by typical *excavata*, which attains spacings of 2.4 mm. In the Wolfcamp formation of the Glass Mountains, as well as in the underlying "*Uddenites*-zone" which is probably basal Permian, cylindrical fragments of *Heliospongia* occur which show the same horizontal-tract spacing as typical *ramosa* (0.9–1.2 mm.), Most of these sponges are larger than typical *ramosa*, some attaining diameters of 50 mm. In the same beds there also occur sponges of equivalent or greater diameter which have the closer tract spacing characteristic of *H. vokesi* (0.6–0.9 mm.).

The only characters by which *vokesi* can be distinguished from *ramosa* are its larger size and closer tract spacing. The Wolfcampian sponges show a range of variation that seems to span the gap between typical *ramosa* and typical *vokesi* with little discontinuity. An elaborate statistical study with more material than is presently available would be necessary to demonstrate that no discontinuity exists. It seems likely, however, that the Wolfcampian specimens represent unitary biological populations that are in an intermediate stage of phyletic evolution between typical Pennsylvanian populations of *ramosa* and typical Leonardian populations of *vokesi.* Most of the Wolfcampian individuals in the present collections, however, can be placed in one of two groups, namely, those with horizontal-tract spacing greater than 1.0 mm. and those with spacing less than 1.0 mm. This criterion has been arbitrarily used in the present paper for purposes of classification, the former being referred to *ramosa* and the latter to *vokesi.*

Girty (1908, p. 290) separated from typical *ramosa* a variety *parallela* based on a specimen from the same locality in which two parallel branches arise at right angles from a single parent branch. Except for this peculiarity of the branching, there are no other differences between this specimen and the holotype of *ramosa.* Indeed, the latter specimen shows both branching at right angles as well as parallelism of adjacent branches, although they do not occur in combination. It does not seem worth while to recognize such accidents of growth form by varietal names.

R. H. King (1943, p. 20) based the new species *Stylopegma conica* King on a single fragment of a sponge from the Wolfcamp formation. The present writer has examined this specimen as well as the type specimens of the genotypic species, *Stylopegma dulce* King, 1943. The genotype is a thalamid calcisponge, closely related to *Amblysiphonella* Steinmann. *Stylopegma conica*, however, appears to be a fragment of the body wall of a large *Heliospongia.* The tract spacing is that of *H. ramosa* rather than *H. vokesi.* No oxeas could be seen in the coarsely silicified tracts.

MATERIAL: The type lot contains about a dozen calcified specimens, together with five thin sections. The holotype is a slab of argillaceous limestone bearing one or more elaborately branching and nearly complete individuals weathered out on its surface. From U.S.N.M. 518p there are four similarly preserved, large, dendroid fragments, as well as 35 fragments of individual cylinders. Four specimens are available from U.S.N.M. 518o. More than a dozen fragments of cylindrical branches are available from the various localities in the Wolfcamp formation. Some are silicified and have been prepared with acid, but most are calcified specimens.

OCCURRENCE: *Horizons:* Upper Missourian; Wolfcampian. *Localities:* U.S.G.S. 2520 green; U.S.N.M. 518o, 518p, 701d, 705k, 705v, 706g, 707j. *Biotopes:* Pennsylvanian shelf facies; Wolfcampian shale facies; Wolfcamp patch-reef facies. *Lithotopes:* Argillaceous limestones, calcareous shales, biohermal limestones.

TYPES: Holotype, U.S.N.M. No. 53472, from U.S.G.S. 2520 green; paratypes, U.S.N.M. Nos. 53472, 53473; illustrated hypotype, U.S.N.M. No. 127583.

Heliospongia vokesi R. H. King, 1943

Plate 1, figure 7; plate 2, figures 4, 9;
plate 4, figures 1–5

H. vokesi R. H. KING, 1943, p. 8, text fig. 1, pl. 1, figs. 1, 2.

? *Aulacospongia* sp. TERMIER AND TERMIER, 1955, p. 628.

? Hyalosponges, undetermined, TERMIER AND TERMIER, 1955, figs. 10f–h.

DIAGNOSIS: Large, openly branching cylinders of greater diameter than those of either *ramosa* or *excavata*, each with a deep, relatively broad, central cloaca opening terminally; horizontal layers spaced more closely than in either *ramosa* or *excavata*, being less than 1.0 mm. apart; ascending tracts spaced as in *ramosa*, approximately 0.6 mm. apart.

DESCRIPTION: The sponges of this species are large cylinders, 25–125 mm. in diameter, which branch at wide angles. Each cylinder contains an axial cloaca, 9–50 mm. in diameter. The cloacal ratio ranges from 1:2 to 1:5. The cloacae of the branches are apparently not connected with those of the parent stem but begin a short distance above the point of origin. Adjacent branches may anastomose upward, and in this case the two cloacae join together. Each cloaca opens terminally as an osculum of the same diameter. The upper surface of the branch is evenly rounded and meets the vertical walls of the cloaca at a right angle; this upper surface is parallel to the horizontal tract layers. During growth of the sponge the lower part of the cloaca is filled in, from below upward, with dense skeletal material that does not have the regular arrangement of tracts characteristic of the body wall. The apochetes from the lower portion of the sponge penetrate this secondary filling and rise vertically through it to open at the base of the unfilled cloaca; they are frequently concentrated about the periphery of the filled portion. (See pl. 4, fig. 4.) Similar structureless secondary skeletal material may form sharp-crested vertical ridges on the sides of the cloaca; these ridges may have a slightly spiral course. (See pl. 4, figs. 2, 3.) Large circular prosopores, 0.5–2.0 mm. (mostly 1.2 mm.) in diameter, are spaced 2.0–5.0 mm. apart over the exterior surface. Some of them show a substellate outline produced by short surface canals that converge upon them. Between the large prosopores are smaller circular pores, 0.1–0.6 mm. (mostly 0.3–0.4 mm.) in diameter, spaced 0.5–0.7 mm. apart. The large prosopores lead into prosochetes of the same diameter, which follow the ascending spicule tracts inward and downward at least halfway through the body wall of the sponge. Large circular apopores, 0.5–1.8 mm. (mostly 1.2–1.8 mm.) in diameter, line the cloacal surface. They are spaced 1.2–4.0 mm. apart and tend to be aligned in horizontal, and sometimes vertical, rows. Between them are closely spaced small circular pores, 0.2–0.4 mm. (mostly 0.3 mm.) in diameter and 0.5–0.7 mm. apart. The larger apopores are the openings of apochetes of the same diameter which run upward and inward through more than half of the thickness of the body wall, following the horizontal tract layers. The ascending tracts radiate from the axial region of the sponge and meet the outer surface perpendicularly. They are spaced 0.3–1.2 mm. (mostly 0.6–0.9 mm.) apart, new tracts being added peripherally by intercalation. The horizontal tract layers curve downward peripherally so as to be tangent to the outer surface; they are spaced 0.3–0.9 mm. (mostly 0.6 mm.) apart. Both sets of tracts are 0.1–0.5 mm. (mostly 0.3–0.4 mm.) in diameter. The oxeas of which they are composed are 0.12–0.48 mm. long and 0.012–0.036 mm. wide.

BIOLOGICAL OBSERVATIONS: The filling of the lower part of the cloaca during ontogeny with a dense mass of irregularly disposed spicule tracts, which is so readily observed in the large cloacae of this species, is probably characteristic of the whole genus. This is suggested by the presence of similar, poorly preserved, skeletal material in the cloaca of one of the paratypes of *H. ramosa* (illustrated here in pl. 3, fig. 4). Although oxeas have not been demonstrated within this secondary filling, the fact that apochetes commonly penetrate it leaves little doubt that it was formed by the sponge. A shell of the brachiopod *Hustedia* and several shells of the gastropod *Glyptotomaria marginata* Batten, 1958, have been found embedded in this filling material. These shells undoubtedly found their way into the cloaca of the sponge while it was alive. The case of the snail is particularly interesting, because Roger L. Batten and the writer have found four specimens of *H. vokesi* from U.S.N.M. 702d, in which at least one shell of *Glyptotomaria marginata* was present in the cloaca. The specimen illustrated on plate 4, figure 5 (also published in Batten, 1958, as pl. 42, fig. 9) contains three of these snails, two of which are clearly embedded in the skeletal filling of the cloaca. These repeated occurrences suggest that the cloaca of *H. vokesi* was at least one of the habitats of this species of snail, and that the relationship may even have been a regularly commensal one. Batten (1958, pp. 169–170) has discussed this possibility with reference to the probable feeding habits of the snail. He also points out the fact that a related, undescribed species of *Glyptotomaria* from middle and upper Pennsylvanian beds is commonly associated with cloacate sponges, which may indicate a long-established symbiotic association of some sort. It is not likely, however, that the Pennsylvanian snails lived within the sponge cloacae, because the only sponges that could have been so used, namely, *Heliospongia* and the calcareous sponge *Wewokella*, had, during the Pennsylvanian, cloacae much narrower than the average diameter of the snails. It is possible that the large cloaca of *Heliospongia vokesi* may have served as a trap for the snails, and that once having entered the deep vertical cloaca, they were unable to leave it. Another snail, probably a species of *Strobeus* (*fide* Batten, personal communication), has been found within the cloacae of two specimens of *H. vokesi* at U.S.N.M. 702d. These were not embedded in the sponge skeleton and may therefore have been swept into the sponge as it was buried in the sediment.

The exterior of *H. vokesi*, as in the other species of the genus, served as an attachment for various sessile invertebrates such as corals, Bryozoa, and brachiopods. In most cases there is no indication whether or not the sponge was alive at the time, but two of the brachiopods (see pl. 4, fig. 1) are embedded in the sponge skeleton and were undoubtedly present while the sponge was alive.

DISCUSSION: There is no difficulty in referring any of the Leonardian representatives of *Heliospongia* to the present species on the basis of the diagnostic characters of size and tract spacing. The Wolfcampian populations, which are intermediate between *ramosa* and *vokesi*, have been divided arbitrarily on the basis of tract spacing. Termier and Termier (1955) have described two sponges from the Permian (probably Leonardian) of Tunisia which may be representatives of this species. One of them, described as "*Aulacospongia* sp.," was not illustrated, but the description fits that of *Heliospongia* very closely, especially the form of the skeletal net and the presence of spiral ridges on the cloacal surface. The other sponge, described as an undetermined hyalosponge, resembles *Heliospongia* in gross morphology, but no data on the skeletal net were given.

MATERIAL: About 130 specimens were studied. All were silicified except those from U.S.N.M. 707o and 715, which were calcified. Most of the localities yielded four or fewer specimens except U.S.N.M. 705a (about 45 specimens, including the holotype), 702d (46 specimens), and 707o (eight specimens). The most complete individuals were from U.S.N.M. 702d.

OCCURRENCE: *Horizons:* Wolfcampian to middle Leonardian. *Localities:* A.M.N.H. 381, 510; P.U. 48sd, 60a, "Pebble beds of Bone Spring at head of Victorio Canyon"; U.S.G.S. 8543, 8562, 14429, 14454; U.S.N.M. 701, 702d, 705a, 705k (?), 707m, 707o, 715. (Glass Mountains and Sierra Diablo.) *Biotopes:* Wolfcamp shale facies, Wolfcamp patch-reef facies, Leonardian patch-reef facies, Leonardian back-reef facies (Sierra Diablo). *Lithotopes*: Light bioclastic limestones, dolomitic limestone, limestone conglomerates, calcareous shales.

TYPES: Holotype, A.M.N.H. No. 25227 (from vicinity of U.S.N.M. 705a); paratype, A.M.N.H. No. 25228; hypotypes, A.M.N.H. No. 28088, U.S.N.M. Nos. 127585, 127587, 127588a–127588d.

GENUS **COELOCLADIA** GIRTY, 1908

Coelocladia GIRTY, 1908, p. 287.

DIAGNOSIS: Sponge consisting of small, branching cylinders which may expand upward to form a large funnel or concave frond; body wall relatively thin and cloaca broad; skeletal net relatively loose and open, with slender spicule tracts; ascending tracts and horizontal tracts spaced the same distance apart; horizontal layers not strongly downturned at periphery; dense, nearly imperforate dermal layer present which may form tubular collars about the circular prosopores; cloaca lined by dense but perforate layer; apopores smaller than the prosopores and arranged in horizontal rows.

DISCUSSION: Only one species can be recognized in this genus. At most of the localities only the cylindrical growth form occurs. The funnel-shaped and frondose forms are restricted to the Graford formation (Brownwood shale and Rock Hill limestone) in the vicinity of Bridgeport, Texas, though a fragment, possibly of this form, is known from the equivalent horizon of the Gaptank formation (bed 10) in the Glass Mountains. Inasmuch as the cylindrical forms also occur at these localities, frequently growing as branches from the frondose forms, it does not seem advisable to recognize them as separate species.

The presence of an imperforate dermal layer distinguishes this genus from the other two genera of the family. It differs further from *Heliospongia* in its smaller dimensions—not only the size of the whole sponge but also the spacing of the spicule tracts and the size of the oxeas themselves. The range of oxea length in the three species of *Heliospongia* is fairly constant, being 0.12–0.50 mm. The oxeas of *Coelocladia* do not attain so great a length, their range being 0.10–0.30 mm. The thickness of the tracts shows a greater difference, each of the species of *Heliospongia* having the range of 0.10–0.50 mm. and *Coelocladia* having the range of 0.03–0.10 mm. In tract spacing *Coelocladia* differs not only in having the tracts more closely spaced but also in that there is little difference between the spacing of the horizontal tracts and that of the ascending tracts. In *Heliopongia* a more or less uniform tract spacing is present in *H. vokesi*, but in *ramosa* and in *excavata* the horizontal tract layers are more widely spaced than the ascending tracts. Tract spacing in *Coelocladia spinosa* is about 0.25 mm., whereas the total range of tract spacing, of both kinds, in *Heliospongia* is 0.30–2.4 mm. *Coelocladiella* is close to the present genus in its possession of dense dermal and gastral layers, as well as in the thinness of the body wall. Apart from the imperforate dermal layer in *Coelocladia*, this genus differs from *Coelocladiella* in the more regularly arranged tracts and in the more widely spaced prosopores.

GENOTYPE: *Coelocladia spinosa* Girty, 1908. This is the sole species.

OCCURRENCE: Desmoinesian to Virgilian; south central United States.

Coelocladia spinosa Girty, 1908

Plate 5, figures 1–8, plate 6, figures 1–13,
plate 7, figures 4–6; plate 8, figure 9

Coelocladia spinosa GIRTY, 1908, p. 288, pl. 16, figs. 1–7. R. H. KING, 1933, p. 83, pl. 8, fig. 7.

DIAGNOSIS: Slender cylinders, in some individuals expanding upward into strongly asymmetrical funnels which may continue as broad, laterally curved fronds; branching relatively open but in some specimens subparallel; cloaca of cylindrical parts approximately one-third of the sponge diameter.

DESCRIPTION: The sponges of this species occur in two principal forms which intergrade with each other. The more common form, which can be found at every locality, is that of small cylinders, which branch at wide angles to form dendroid or digitate individuals. The branches usually curve upward so that they are parallel to one another. Lateral fusion of adjacent branches has also been observed. In general the form of these individuals is that of *Heliospongia ramosa* or *H. vokesi*, though on a much smaller scale (see pl. 6, fig. 4). Branch diameters range from 2.0 mm. to 25 mm., and each has a central cloaca occupying from one-third to one-half of the diameter of the sponge. Individual branches attain lengths of more than 70 mm. At some localities a few individuals expand upward, assuming a conical form. This tendency reaches its highest development in the populations from the Graford formation (Brownwood shale and Rock Hill limestone) in the vicinity of Bridgeport, Texas. Here the second type of growth form is most abundant, the majority of the sponges consisting of asymmetrical, spirally twisted funnels which may expand into broad, hemicylindrical fronds. The funnels range in diameter from 35 mm. to 62 mm. and may stand more than 130 mm. high. The body wall maintains a more or less constant thickness, ranging from 0.3 mm. to 3.0 mm., so that the cloaca is much enlarged as the funnels expand upward. Cylindrical branches may arise from the exterior surfaces of the funnel-shaped or frondose individuals. As in all cases of branching in this species, the cloaca of the branch does not communicate with that of the parent stock.

The external surface of the sponge is covered with a dense dermal layer 0.05–0.30 mm. thick, which is perforated only by large circular prosopores, 0.20–0.50 mm. (mostly 0.35 mm.) in diameter, more or less evenly distributed 0.6–2.0 mm. (mostly 1.5 mm.) apart. The dermal layer is commonly produced as a tubular lip about each pore and may form a hollow spine as much as 1.5 mm. long. The cloacal surface is lined with a similar dense layer 0.15–0.50 mm. thick, which is perforated by closely spaced small and large circular apopores. The large apopores are commonly organized into horizontal rows 1.2–1.5 mm. apart and are spaced generally less than a millimeter apart in each of the rows. These pores are 0.1–0.6 mm. (mostly 0.3–0.4 mm.) in diameter. The smaller pores, 0.02–0.18 mm. in diameter, are closely spaced over the intervening areas, 0.08–0.30 mm. apart. The prosopores lead into prosochetes of the same diameter and extend inward and downward, parallel to the ascending tracts, for at least half of the diameter of the body wall. They do not seem to branch. The apochetes tend to follow the horizontal tracts and are the same diameter as the large apopores. Each apochete originates in the peripheral parts of the body wall, just within the dermal layer, as oblique branches which unite about halfway through the wall to form a single, straight canal which passes radially into the cloaca. The spicule tracts are 0.03–0.10 mm. thick and are organized into upwardly arched horizontal tracts, which meet the dermal layer at a considerable angle, and upwardly divergent ascending tracts at right angles to them. The spacing of both sets of tracts is approximately the same, about 0.25 mm. The tracts are bundles of parallel, smooth, slightly curved oxeas, 0.10–0.30 mm. long and about 0.015 mm. thick.

DISCUSSION: The funnel-shaped and frondose growth form appears to have been a local development during the middle Missourian in the north central Texas area, although one specimen from the contemporaneous bed 10 of the Gaptank formation of west Texas appears to have the same form. Ordinary cylindrical forms are present at the same locality, in some specimens as branches from the frondose forms. There are no other observable differences between the two types of specimens, and they are probably best considered as members of a single species. It is worthy of note that the distribution of this growth form coincides with that of typical *Heliospongia excavata*. It may be that the frondose form in the one, and the flabellate form in the other, are comparable responses to special environmental conditions. At the other Pennsylvanian localities, an almost identical ramose growth form is assumed by both *Coelocladia spinosa* and by *Heliospongia* (both *H. excavata* and *H. ramosa*).

Coelocladia spinosa var. *major* Hayasaka, 1923 (p. 108, pl. 15, figs. 1–3) does not appear to be a *Coelocladia*, so far as can be determined from the description and illustrations. It may belong to the calcareous sponge genus *Wewokella* Girty. The same must be said for *Coelocladia? tangchiensis* Reed, 1927 (p. 98, pl. 7, figs. 2, 2a).

MATERIAL: The type lot consists of more than 100 calcified fragments, and includes four type thin sections. About a dozen silicified specimens are available from U.S.N.M. 518g, and about two dozen calcified ones from U.S.N.M. 518f; these two localities include mostly funnel-shaped forms. About 45 fragments are available from the several other localities, most of them calcified.

OCCURRENCE: *Horizons:* Desmoinesian to Virgilian. *Localities:* U.S.G.S. 2520 green; U.S.N.M. 510b, 518f, 518g, 518i, 518j, 518k, 518L, 518m, 518p, 700, 3302, 3305; Cisco group, Graham, Young County, Texas. *Biotope:* Pennsylvanian shelf facies. *Lithotopes:* Calcareous shales, argillaceous limestones.

TYPES: Lectotype, U.S.N.M. No. 53469a (illustrated in Girty, 1908, pl. 16, fig. 2), from U.S.G.S. 2520 green. Girty designated two cotypes, of which the one mentioned here is chosen as lectotype by the present writer. Paratypes, U.S.N.M. No. 53469b–53469 p. Hypotypes illustrated in the present paper: U.S.N.M. Nos. 127589, 127590, 127591a–127591f, 127592, 127593a–127593 l.

COELOCLADIELLA FINKS, NEW GENUS

DIAGNOSIS: Sponge cylindrical to conical, with thin body wall and very broad cloaca; skeletal net less regular and more open than in *Heliospongia* and *Coelocladia*, with slender flattened tracts that frequently curve, anastomose, and are interrupted by canals; outer surface smooth, with closely spaced, circular prosopores; cloacal surface similar, but apopores may be smaller.

DISCUSSION: The two species of this genus are separated chiefly on the basis of: (1) body form, (2) thickness of body wall, (3) size and distribution of pores, and (4) thickness of spicule tracts. This genus is assigned tentatively to the Heliospongiidae on the basis of its gross morphology, for no spicules have been observed, and the reference to certain structures as spicule tracts is made purely by analogy. The general anatomy of these forms is also similar to that of certain calcareous sponges of the Order Thalamida De Laubenfels, 1955, which occur in the same faunules, namely, the Pennsylvanian genus *Maeandrostia* Girty, 1908, and the Pennsylvanian and Permian genus *Amblysiphonella* Steinmann, 1882, together with its possibly congeneric Permian relative *Stylopegma* R. H. King, 1943. The present genus resembles these calcisponges not only in its general tubular form, but also in the presence of a definite cloacal and dermal layer pierced by circular pores, and by the fact that the internal skeletal elements are more partition-like and curving than is the case with the spicule tracts of *Heliospongia* and *Coelocladia*. The latter genus, however, also possesses a distinct cloacal and dermal layer, and its spicule tracts are fairly close in form to the corresponding structures of the present genus. These similarities to *Coelocladia*, together with the fact that its skeletal net is notably denser than that of the above-mentioned calcisponges, are the chief reasons for including *Coelocladiella* among the heliospongiids. A further similarity to *Coelocladia*, which is not in itself sufficient to exclude *Coelocladiella* from the calcisponges, is the relative thinness of the body wall.

In addition to the features of the internal skeleton mentioned above, both species of the present genus differ from *Coelocladia* in the smaller size and closer spacing of prosopores, as well as in the absence of an imperforate dermal layer.

GENOTYPE: *Coelocladiella lissa*, new species (Missourian, Wolfcampian; Texas).

INCLUDED SPECIES: *Coelocladiella lissa*, new species (Missourian, Wolfcampian); *C. philoconcha*, new species (Wolfcampian).

OCCURRENCE: Missourian, Wolfcampian; Texas.

Coelocladiella lissa Finks, new species

Plate 7, figures 7–9; plate 8, figure 8

DIAGNOSIS: Sponge cylindrical and very thin-walled; outer surface covered with closely spaced circular pores, between which are much finer pores; gastral surface poorly known, but apparently covered with a dense layer pierced only by pores the size of the smaller external pores; tracts very thin; spicules not known.

DESCRIPTION: This sponge is known only from fragments, all of which are parts of thin-walled, slightly conical, cylindrical tubes. Their diameters range from 7.0 mm. to 30 mm., and the walls are 2.0–4.0 mm. thick. The smooth exterior is covered with large, circular prosopores 0.25–0.65 mm. (mostly 0.4–0.5 mm.) in diameter, separated by spaces of approximately the same width. These intervening spaces bear fine pores 0.10–0.25 mm. in diameter. The nature of the cloacal surface is poorly known, because it could be observed only in cross section on the specimens from the type locality. In these specimens the cloaca seems to be lined with a dense layer 0.15–0.30 mm. thick, pierced only by fine pores, 0.08–0.20 mm. in diameter, separated by spaces of about the same dimensions. This finely perforate layer appears to cover the ends of the apochetes, which have the same diameter as the prosopores and prosochetes. However, a silicified specimen from the Wolfcampian locality U.S.N.M. 715d (pl. 8, fig. 8), which in other respects resembles the type material, shows, on its well-exposed cloacal surface, apopores of similar size and distribution to the prosopores. Its cloacal surface has the appearance to be expected if the finely perforate cloacal layer of the type material were removed. Unfortunately, the matter must rest here until better material is available from the type locality. The prosopores of the exterior surface open into straight prosochetes of the same diameter which lead radially inward and downward. Their walls are sharply defined by a solid layer of mineral skeleton about 0.08 mm. thick which is pierced by small pores 0.1 mm. in diameter, separated by distances greater than their diameters. The prosochetes extend one-half to two-thirds of the distance into the body wall, maintaining the same diameter. They appear to end rather abruptly without branching, and open into the regular skeletal mesh. The apochetes have the same dimensions and characteristics, except that they are more or less horizontal, or perhaps run obliquely upward towards the cloaca. The internal skeleton is known only from sections, in which it appears as a network of curving, anastomosing, and subparallel elements about 0.05 mm. thick, which separate interconnecting canals of circular cross section, 0.13–0.26 mm. in diameter. As seen in longitudinal section, the skeletal elements form more or less continuous strands which run in an upward and outward direction, connected at frequent intervals by similar strands at right angles to them. This pattern is essentially the same as that seen in *Coelocladia*, though it is less clearly developed. In cross sections the general pattern of the strands is radial, connected at intervals by concentric elements. No spicules could be seen within any of these skeletal elements.

DISCUSSION: The specimens from the Gaptank formation (bed 10) show little variation in their characters. A fragment from the somewhat earlier Palo Pinto limestone (U.S.N.M. 510c) appears to belong to this species. The only other possible occurrence of the species is the silicified specimen from the Wolfcamp formation (U.S.N.M. 715d) referred to in the description above. This is the sole specimen on which the cloacal surface is exposed, and, as stated earlier, it shows much larger apopores than were inferred for the type material. This may be a different species, or, on the other hand, it may show the character of the cloacal surface more truly than can be interpreted from the type material. This species seems to take the place of *Coelocladia spinosa* in the sponge fauna of the Gaptank formation. True *Coelocladia spinosa* appears to be present at this locality in small numbers; it shows some similarity to *Coelocladiella* in that the tubular collars about the prosopores are much reduced, so that the surface is less spinose than is usual in that form. *Coelocladiella lissa* can be distinguished from *Coelocladia spinosa* by the smooth outer surface, and by the much greater diameter than is seen in cylindrical specimens of the latter form. The present species is readily distinguished from *C. philoconcha* by its broader cloaca and cylindrical, rather than conical, shape.

MATERIAL: Thirty-seven calcified fragments were available from the Gaptank formation, one fragment from U.S.N.M. 510c, and one silicified and acid-prepared specimen from U.S.N.M. 715d.

OCCURRENCE: *Horizons:* Missourian; possibly Wolfcampian. *Localities:* U.S.N.M. 700, 700a, 510c, and possibly 715d. *Biotopes:* Pennsylvanian shelf facies; possibly Wolfcampian patch-reef facies. *Lithotopes:* Argillaceous limestone; possibly biohermal limestone.

TYPES: Holotype, U.S.N.M. No. 127595 (from U.S.N.M. 700); paratype, U.S.N.M. No. 127596.

Coelocladiella philoconcha Finks, new species

Plate 8, figures 1–7

DIAGNOSIS: Sponge conical and in some specimens branching; body wall relatively thick; outer surface covered with closely spaced circular pores of the same size as the large pores in *lissa*, finer pores not seen; gastral surface essentially identical to outer surface; tracts relatively coarse; spicules not known.

DESCRIPTION: These are small conical sponges with a well-developed cloaca. Some individuals are basally attached to others as though they were branches or buds. In no case are the cloacas of the two individuals connected, and the branch may be merely a separate sponge which fortuitously settled on the first. The sponges commonly show slight periodic contractions and expansions during the course of growth, somewhat resembling those of a rugose coral. The sponges range in diameter from 4.0 mm. to 30 mm., and the largest specimen is 60 mm. high. The cloaca may be absent from the lower end of the sponge, and increases in diameter, relative to that of the sponge, during the course of growth. The cloacal ratio is generally about 1:4, but increases towards the upper end of large specimens to as much as 2:3. The body wall is 4–10 mm. thick. The exterior is smooth and bears closely spaced circular pores 0.1–0.5 mm. (mostly 0.3 mm.) in diameter, which are separated by spaces of similar width. The cloacal surface contains pores of similar size and spacing, but also much larger ones up to 0.65 mm. in diameter. These pores tend to be arranged in vertical and horizontal rows. The interior part of the skeleton consists of rod- to blade-like elements, 0.2–0.3 mm. thick. Some of these elements are radially disposed perpendicular to the periphery 0.5–0.7 mm. apart and are connected by horizontal elements, rather regularly spaced, 0.6–0.8 mm. apart. The junctions of these elements tend to be rounded, so that the interspaces are more or less circular. The radial elements are often evident as ridges on the top surface of the sponge. No spicules could be seen.

BIOLOGICAL OBSERVATIONS: Almost all the specimens of this species are from a bioherm in the Wolfcamp formation which consists largely of brachiopods and sponges (U.S.N.M. 701L). The individuals of this species are intimately intergrown with shells of the brachiopod genera *Derbyia* and *Meekella*. Many of the brachiopods are molded to the sides of the sponges, and the sponges, in turn, have overgrown many of the shells. This clearly indicates that the several animals involved were alive simultaneously and formed parts of a living reef. A thalamid calcisponge related to *Fissispongia* King, 1933, also occurs in this reef, but is not intergrown with the present form. A few specimens have also been recovered from a similar Wolfcampian bioherm (U.S.N.M. 701h).

DISCUSSION: The conical shape, larger pores, and coarser skeleton readily distinguish this species from *C. lissa*, to which, indeed, it may not be related. The present species, more than *C. lissa*, shows considerable similarity to certain thalamid Calcispongea, particularly to undescribed relatives of *Amblysiphonella* Steinmann, in which the chambers are very low and filled with pillar- and partition-like elements. In the present form, however, there is no clear subdivision into chambers, although the horizontal elements tend to form more or less continuous partitions.

MATERIAL: About 15 complete, or nearly complete, specimens are known from the type locality, U.S.N.M. 701L, and a few fragments from U.S.N.M. 701h. All are coarsely silicified and were prepared with acid.

OCCURRENCE: *Horizon:* Wolfcampian (Wolfcamp formation). *Localities:* U.S.N.M. 701h, 701L (Glass Mountains). *Biotope:* Wolfcamp patch-reef facies. *Lithotope:* Biohermal limestone.

TYPES: Holotype, U.S.N.M. No. 127598 (from U.S.N.M. 701L); paratypes, U.S.N.M. Nos. 127597a–127597c.

ORDER **LITHISTIDA** SCHMIDT, 1870

DIAGNOSIS: Spicules of main skeleton tetraxons or monaxons which bear irregular branching excrescences, especially at the tips of the rays; skeleton rendered rigid by the interlocking of these processes.

DISCUSSION: The suborders of this taxon are separated on the fundamental form of the principal spicules of desmas. Most students of sponges have noted the possibility that this order is polyphyletic, embracing several different lines of demosponges which have independently developed the desma type of spicule. Unfortunately the relationships between the living members of the demosponges have not been satisfactorily established, and the fossil record is too incomplete at present to shed much light on the matter. A large proportion of the known lithistid species contain both monaxonic and tetraxonic spicules, and recognition of lineages within the order will probably have to be based on other types of characters in addition to spicule symmetry. The former subdivision of the living spicule-bearing demosponges into monactinellids and tetractinellids has been abandoned by most modern students of the group. The present classification of the lithistids is still essentially that established by Zittel (1878). Those forms in which the principal spicules are clearly tetraxonic, with the arborescent processes confined to the tips of the rays, are included in the suborder Tetracladina. The suborder Rhizomorina includes forms with both monaxonic and tetraxonic spicules in which arborescent processes are distributed over most of the spicule. The Megamorina have spicules which resemble those of the rhizomorines, but are larger, coarser, less regular, and less intricately branched. The remaining suborders, the Anomocladina of Zittel, and the Eutaxicladina, later established by Rauff, have spicules with a variable number of rays diverging from a central point, or points. The dicranoclone type of spicule, found in some families of the Eutaxicladina, is essentially a simple tetraxonic spicule with one ray reduced. The more complex type of spicule, called "ennomoclone," found in the remaining members of these groups may represent various modifications of tetraxons, but the relationship is less clear. There is a distinct suggestion in the fossil record that the primitive type of demosponge spicule was monaxonic and that the more complex spicules arose phylogenetically by fusion of separate monaxons. The earliest lithistids are anthaspidellids, astylospongiids, and hindiids. The spicules of the anthaspidellids are dendroclones which are very nearly monaxonic. In terms of the fossil record, regular tetraxonic desmas (tetraclones) seem to have arisen in descendants of this group by the development of three rays at one end of the essentially single-shafted dendroclone. At least, regular tetraclones become more abundant at the expense of dendroclones in later families which appear to be related to the anthaspidellids. The dendroclones of the anthaspidellids have a two-dimensional, spoke-like arrangement in the skeletal net. The net of the astylospongiids has essentially a three-dimensional, spoke-like pattern, the individual rays of the multirayed ennomoclones resembling single dendroclones. Possibly these peculiar spicules arose by fusion of separate dendroclones. The dicranoclones of the hindiids are basically tetraxonic. However, this type of tetraxon may have developed quite independently of the tetraclones found in the Tetracladina and may not represent therefore a reduced tetraclone. Examination of many types of lithistids has left the writer with the strong impression that the form of the spicules is determined by the over-all geometry of the skeletal net, rather than the other way round. It is, of course, difficult to demonstrate which of two correlated characters is cause and which effect, but the presence, in local areas of an individual sponge, of special types of spicules clearly related to their position in the skeletal net strongly suggests that the morphology of the skeletal net determined the development of the spicule, at least in those cases. Such cases are (1) the rhizoclone-like spicules formed in *Anthracosycon* in which the spicules are crowded in bundles between the canals, (2) the dendroclones seen in the earlier-formed layers of the same sponge, as well as in the rhizomorine sponge *Haplistion*, and (3) the curved rhizoclones, seen in many tetracladine species, which outline pores and canals. Although these cases involve only the ontogeny of individual sponges, it is equally possible that in the phylogenetic origin of the main groups of lithistids, the form of the skeletal net was the primary genetic factor, and the shapes of the principal spicules followed from this. It is, therefore, possible that the presently accepted suborders of the lithistids are themselves polyphyletic, and that the tracing of lineages within the lithistids should lay greater emphasis on the form of the skeletal net and less emphasis on the form of the individual spicules.

The foregoing remarks are not meant to deny that the basic form of the spicule is genetically determined. The individual cases cited above probably represent developmentally determined differences of form in a single genetically determined type of spicule. It is suggested, however, that the viability of genetically new forms of spicules may be determined by a pre-existing, and genetically independent, structural pattern of the sponge. Dendy, who has perhaps devoted more attention to the evolutionary significance of spicules than other workers on living sponges (see especially Dendy, 1921), believed that spicule form was in its evolutionary origin essentially non-adaptive and that the function of particular spicule forms in parts of the skeletal net was secondary to their origin. He cited as evidence the fact that the specialized dermal spicules of many sponges are formed in the interior of the sponge and are then carried to the surface during growth, and also cited the fact that closely related genera often have widely different dermal spicules. Although these facts indicate that the form of the spicule in the cases cited by Dendy was genetically determined and developed independently of its position in the structure of the sponge, such need not have governed the original fixation of the spicule form in the genotype of the species. Many of the bony structures of vertebrates, for example, the gill arches, appear in the embryo in positions different from those assumed in the adult animal.

SUBORDER **TETRACLADINA** ZITTEL, 1878

DIAGNOSIS: Principal spicules tetraxonic.

DISCUSSION: The families of this suborder are separated chiefly on the basis of: (1) the varieties of tetraxonic desmas present, (2) their geometric arrangement in the skeletal net, (3) the architecture of the canal system, and (4) the nature of the dermal specialization. The first two characters are to some extent correlated with each other. Families in which the skeletal net has a very regular arrangement tend to have spicules of the dendroclone type. Such is eminently true of the Anthaspidellidae and, to a lesser extent, of the Anthracosyconidae. In the first of these, the spicules are oriented parallel to the sponge surface and are arranged in radial rows. In the second they are oriented perpendicular to the surface and are arranged in concentric layers. The Chiastoclonellidae show an obscure arrangement of the spicules in radial rows, and the spicules are chiastoclones, which are somewhat intermediate in form between dendroclones and normal tetraclones. The remaining families have a more random arrangement of the spicules in the skeletal net, and the preponderance of the spicules appear to be normal tetraclones. In the Anthracosyconidae the tendency for the spicules to be grouped in bundles leads to the development of lateral processes on the normally smooth rhabdomes, whereby adjacent spicules are united with one another. Such spicules resemble rhizoclones. Another type of rhizoclone-like spicule is found in many tetracladine families, outlining pores and canals. This is a curved and apparently monocrepid spicule, with a smooth concave side facing the canal opening and a convex side bearing arborescent processes that articulate with the neighboring spicules. These rhizoclone-like types may or may not be homologous to the presumably monaxonic spicules of the true rhizomorine sponges. The existence of these various types of spicules in different families and suborders points up the difficulty of recognizing even the higher categories of lithistids from single isolated spicules. The earliest tetracladines are anthaspidellids (Ordovician). The chiastoclonellids first appear in the Silurian, and the anthracosyconids in the Permian. The remaining families of the Tetracladina are known only from Jurassic and later rocks, with the possible exception of the Jereidae, to which has been assigned the new Permian genus *Jereina*. The Permian genera cited by De Laubenfels (1955) from other tetracladine families either belong to one of the above-mentioned families or are not tetracladines at all. All the post-Paleozoic tetracladines have an irregular skeleton, with which is correlated a more irregular architecture of the sponge as a whole. Specialized dermal skeletons are not known from any of the Paleozoic forms but are commonly developed in the Mesozoic and later genera. Moret (1935) notes that all the lithistids show a general trend through geologic time towards a decreased regularity both of spicule form and of external symmetry. This is especially true of the Tetracladina, in which the earliest species, the anthaspidellids, are by far the most regular and symmetrical of the group.

INCLUDED FAMILIES: The only families with Paleozoic forms are the Anthaspidellidae of Ulrich, 1890 (Ordovician–Permian), the Chiastoclonellidae of Rauff, 1895 (Silurian–Permian), the Anthracosyconidae, new family (Permian), and the Jereidae of De Laubenfels, 1955 (Permian–Cretaceous). The remaining families listed by De Laubenfels (1955) are restricted to Jurassic and later rocks.

OCCURRENCE: Ordovician to Recent; worldwide.

FAMILY **ANTHASPIDELLIDAE** ULRICH, 1890

Anthaspidellidae ULRICH, 1890, p. 221. BASSLER, 1941, p. 99.

Archaeoscyphiidae RAUFF, 1894, p. 238. BASSLER, 1927, p. 391; 1941, p. 93. DE LAUBENFELS, 1955, p. E53.

Aulocopiidae RAUFF, 1895, p. 247. DE LAUBENFELS, 1955, p. E52 (in part).

Eospongiidae DE LAUBENFELS, 1955, p. E64 (in part).

DIAGNOSIS: Massive to vasiform sponges; skeleton consists of dendroclones in horizontal orientation, superposed in vertical, or radial, ladder-like series; the series are in mutual contact at the ends of the spicules and are commonly arranged in spoke-like groups about a common axis; no dermal specialization other than imperforate basal layer, which is often concentrically rugose.

DISCUSSION: The genera of this family are separated chiefly on the basis of: (1) over-all body form, and (2) the detailed shape and arrangement of the pores and canals. Almost all the earliest tetracladine lithistids of which we have any record are included in this family, which embraces the vast majority of Ordovician lithistid genera. The fundamental character of the group is the predominance of dendroclone spicules and their very regular arrangement as described in the diagnosis. Dendroclones are essentially tetraclones of the triaene type, in which the rhabdome is very long with respect to the clads and bears terminal arborescences at its distal end of nearly the same diameter as the cladome. In general the cladome end is slightly larger and more clearly trifid, but in some spicules the two ends of the rhabdome cannot be clearly differentiated. A minority of the spicules in most anthaspidellid species are normal tetraclones, and the existence of intergrades between the two types, within a single individual, clearly demonstrates their common origin. The fact that the earliest tetracladine lithistids consist predominantly of dendroclones suggests that the typical tetraclad spicule may have arisen in a stock of sponges the ancestors of which contained only monaxonic spicules. Such a fact is at present not demonstrable from the fossil record. Chiastoclones also occur in minor numbers in many anthaspidellid species. These are essentially amphitetraclones and are derivable from the dendroclone type of spicule. They are characteristic of the closely related and possibly descendent family Chiastoclonellidae described below.

No certain trace of the Anthaspidellidae is known from the Cambrian, but at their first appearance in the Ordovician they are already highly diversified. The internal arrangement of the spicules is remarkably constant in this family, but the external form and the arrangement of the canals and pores are highly variable. The vasiform types range from broad, open cups, often pedunculate and extending laterally as flat sheets, to conicocylindrical sponges with a narrow cloaca. The more massive types commonly have an imperforate basal surface, which is concentrically wrinkled because of the tendency of the convex upper surface to overhang it in the course of growth. Radial architecture of the skeleton and canals is almost always strongly developed. There is a distinct tendency for the radially arranged canals to coalesce laterally so as to form radial slits, but this feature is not present in many genera. Because the form of the spicular net is so characteristic, even a very small fragment of the sponge can be assigned to the family. Isolated dendroclones are suggestive but not diagnostic in themselves, for they also occur as accessory spicules in the Chiastoclonellidae, in the Anthracosyconidae, and in the rhizomorine family Haplistiidae.

The majority of the described genera included in the family are from middle Ordovician rocks of North America. The family forms an important part of the Silurian sponge fauna of both Europe and North America but is less diversified. No species are so far known from the Devonian, and only two genera from the Carboniferous, but the sponge fauna of the Permian of Timor consists almost entirely of members of this family, and one species is known from the west Texas Permian. Undoubtedly future work will reveal many more species from middle and upper Paleozoic rocks, but it is likely that the family had reached its greatest expansion in the early Paleozoic. It is also likely that a critical review of the Ordovician genera will sink many into synonymy.

Ulrich (1890) was the first to characterize this group of sponges, establishing for them the family Anthaspidellidae. This name has clear priority over the family names established by later workers for some or all of the genera here included in the group. One of the generic names included in the family by Ulrich at the time of its founding, *Aulocopium*, was later made the type of the family Aulocopiidae by Rauff (1895). Rauff was apparently unaware of Ulrich's prior establishment of the Anthaspidellidae, and, although Rauff did not include any of the Ordovician genera cited by Ulrich, his definition of the Aulocopiidae is essentially the same as that of Ulrich's family. Rauff included only *Dendroclonella* besides *Aulocopium*. *Archaeoscyphia* was made the type and sole genus of the Archaeoscyphiidae by Rauff (1894). The spicules of this form are poorly preserved, but at least some of those originally illustrated resemble dendroclones, and the general organization of the skeletal net and the gross morphology of the sponge and its stratigraphic occurrence all strongly suggest that it is an anthaspidellid. Bassler (1927, 1941) included in the Archaeoscyphiidae the new genera he established on the sponge fauna from the Ordovician (upper Pogonip) of Nevada. Examination of Bassler's types indicates that all of them, with the possible exception of *Patellispongia*, are almost certainly anthaspidellids as here understood. De Laubenfels (1955) established the family Eospongiidae for a variety of sponges, five of which, including the type, were originally included by Ulrich in the Anthaspidellidae. De Laubenfels' diagnosis of the family is essentially that of Rauff's Anomoclonellidae (Rauff, 1895, p. 226), and De Laubenfels included the two genera (*Pycnopegma* and *Anomoclonella*) that Rauff assigned to that family. This characterization, however, by no means applies to the included anthaspidellids. *Calathium* Billings, 1865, which De Laubenfels included in his Eospongiidae, was assigned tentatively to the Anthaspidellidae by Ulrich, who stated that the genotype might possibly be a hexactinellid (Ulrich, 1890, p. 221). The spicular characters of this genus, and of the possibly related *Trachyum* Billings, 1865, are not known, and their relationships must remain in doubt. The remaining four genera included by De Laubenfels in the Eospongiidae are neither anthaspidellids nor anomoclonellids. The genera included by De Laubenfels in the Archaeoscyphiidae and the Aulocopiidae are all true anthaspidellids with the exceptions of *Defordia* which is here considered a chiastoclonellid and of *Pseudovirgula* Girty, 1909, which is a pharetronid calcisponge.

The list below includes all those genera that the writer believes to belong in the family Anthaspidellidae. The writer has personally examined the original types, or topotypes, of almost all the genera originally included by Ulrich in the Anthaspidellidae and by Rauff in the Aulocopiidae as well as those of the genera established by Bassler. The remaining forms have been assigned here on the strength of their original descriptions and illustrations. The genus *Okulitchina* Wilson, 1948, deserves special mention, for De Laubenfels (1955, p. E81) assigned it to the dictyonine hexactinellids, stating that it was "one of the extremely few Paleozoic sponges having dictyid characters." Apparently on the basis of this one genus, De Laubenfels cited the stratigraphic range of the Order Dictyida as "middle Ordovician to Recent." This is incorrect, for the earliest record of true dictyonine sponges is apparently from the upper Triassic of Germany (Rauff, *in* Assmann, 1937, p. 12). The original illustrations of *Okulitchina* show a skeletal net which may be that of either an anthaspidellid or an astylospongiid. The gross morphology of the sponge and the arrangement of its canals are those of a typical anthaspidellid. The writer believes that it is probably an anthaspidellid; it is almost certainly not a dictyonine hexactinellid.

INCLUDED GENERA: *Calathium* Billings, 1865, and *Trachyum* Billings, 1865, cannot be assigned with any certainty to the family on the basis of our present knowledge. Both genera have been reported from Cambrian rocks, as well as from the Ordovician and Silurian. There are, therefore, no certain occurrences of members of this family prior to the Ordovician.

- Ordovician genera (all from North America)
  - *Allosaccus* Raymond and Okulitch, 1940
  - *Anthaspidella* Ulrich and Everett, 1889[1]
  - *Archaeoscyphia* Hinde, 1889
  - *Calycocoelia* Bassler, 1927
  - *Climacospongia* Hinde, 1883[1]
  - *Edriospongia* Ulrich and Everett, 1889[1]
  - *Eospongia* Billings, 1861
  - *Exochopora* Raymond and Okulitch, 1940
  - *Hesperocoelia* Bassler, 1927
  - *Hudsonospongia* Raymond and Okultich, 1940
  - *Lissocoelia* Bassler, 1927
  - *Nevadocoelia* Bassler, 1927
  - *Okulitchina* Wilson, 1948
  - *Ozarkocoelia* Cullison, 1944
  - ? *Patellispongia* Bassler, 1927
  - *Psarodictyon* Raymond and Okulitch, 1940
  - *Rhopalocoelia* Raymond and Okulitch, 1940
  - *Steliella* Wilson, 1948
  - *Streptosolen* Ulrich and Everett, 1889[1]
  - *Syringophyllum* Ulrich, 1889[1]
  - *Zittelella* Ulrich and Everett, 1889[1]
- Ordovician to Silurian genera
  - *Aulocopium* Oswald, 1846.[1] (Rauff, 1895, established the subgenus *Aulocopella* on an Ordovician species and cited *Silurispongia* Martin, 1878, and *Domospongia* Schlüter, 1887, as junior synonyms of *Aulocopium*.) Europe, North America
- Silurian genera
  - *Aulocopina* Billings, 1874. North America
  - (*Aulocopium* Oswald, 1846,[1] has a Silurian genotype)

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[1] These genera were originally included by Ulrich (1890) when he established the family Anthaspidellidae.

Dendroclonella Rauff, 1895. North America
? *Protachilleum* Zittel, 1877. Argentina
Carboniferous
Stuckenbergia[1] Tschernyschew, 1898. Russia
Carboniferous to Permian
Phacellopegma Gerth, 1929. Carboniferous: Texas; Permian: Timor
Permian genera
? *Aulacospongia* Gerth, 1927. Timor
Mastophyma Gerth, 1927. Timor
Multistella, new genus. Texas
Palaeojerea Gerth, 1927. Timor
Palaeophyma Gerth, 1927. Timor
(*Phacellopegma* Gerth, 1927, has a Permian gentoype)
Pycnospongia Gerth, 1927. Timor
Timorella Gerth, 1927. Timor
"*Virgula?*" Gerth, 1927 (not *Virgula* Girty, 1909). Timor

OCCURRENCE: Ordovician to Permian; worldwide.

GENUS **PHACELLOPEGMA** GERTH, 1927

Phacellopegma GERTH, 1927, p. 103.

DIAGNOSIS: Massive subspheroidal, with radial architecture; surface covered with anastomosing grooves into which the majority of the circular apochetes open, the intervening areas bearing only skeletal pores; interior canals radial, connected by horizontal canals corresponding to the surface grooves.

DISCUSSION: The species of this genus are separated on the basis of the size and spacing of the spicules, pores, and canals. The genus was established with two species, based on specimens from the Permian of Timor. The two original species appear to be distinguishable from each other by the size of the dendroclones and by the depth and linear extent of the surface grooves. The genotype, *P. campanum*, has larger spicules and more prominent grooves than *P. praemorsum*. Both species were based on single specimens, each from a different locality, and therefore the range of variation within a species is not known. The horizon of *P. praemorsum* is Artinskian (Leonardian) and that of the genotype is Kungurian (lower Guadalupian). The new species here assigned to the genus is much older (lower middle Pennsylvanian) but possesses the characters here deemed to be generic. These are essentially the facts that the sponge is massive, without a cloaca, that the apopores open over the whole surface, chiefly concentrated in deep anastomosing surface grooves, and that the apochetes tend to coalesce laterally, parallel to the surface grooves, so that they form radial slits in the interior, which have the same anastomosing pattern. No other anthaspidellid genus has this combination of characters. The new species, *P. schizoderma*, is closer to the genotype but has larger spicules and somewhat smaller grooves and apopores.

Phacellopegma auriculatum Termier and Termier, 1955 (text figs. 9a–c), from the Permian of Tunisia is unfortunately not recognizable from the description and illustrations given, as no information is available concerning its spicules or skeletal net. The same is true of *P. campanum* Gerth, reported by the Termiers from the same collection.

GENOTYPE: *Phacellopegma campanum* Gerth, 1927 [Kungurian (Besleo beds); Timor].

INCLUDED SPECIES: *Phacellopegma campanum* Gerth, 1927 (Kungurian; Timor), *P. praemorsum* Gerth, 1927 [Artinskian (Nifoetassi beds); Timor]; *P. schizoderma*, new species (Atokan; Texas); ? *Phacellopegma auriculata* Termier and Termier, 1955.

OCCURRENCE: Pennsylvanian (Texas); Permian (Timor).

Phacellopegma schizoderma Finks, new species

Plate 9, figures 4–6; plate 10, figures 1, 2

DIAGNOSIS: Surface grooves deep and cleftlike, frequently discontinuous; some isolated large pores scattered irregularly over the smooth surface; horizontal canals of interior radially elongate and slit-like; skeletal net relatively open, with skeletal pores one-fourth to one-half of the size of the apopores.

DESCRIPTION: The single specimen is a plano-convex lenticular individual 63 by 73 mm. in diameter and 30 mm. in maximum thickness. The canals and radial spicule series originate at one side of the flat surface and are more or less parallel to the surface but perpendicular to the convex side. The flat side may be the original base of the sponge, or it may be a broken surface; it shows no special dermal layer. A hole of elliptical cross section penetrates the center of the sponge, passing from the flat to the convex side. It enlarges from a diameter of 8 mm. on the flat side to a diameter of 10 by 17 mm. on the convex side. It does not seem likely that this represents a cloaca, for it seems to bear little relation to the internal radial symmetry of the sponge. It may have been the site of a foreign body. The convex surface is smoothly rounded and bears deep, cleft-like grooves, 0.6–1.2 mm. (mostly 0.9 mm.) wide, which anastomose so as to outline more or less polygonal areas 2.5–7.5 mm. in diameter. The grooves in the vicinity of the large hole in the center of the sponge show an obscurely radial arrangement with respect to it. This may indicate that the hole is actually an anatomical part of the sponge, but it would be equally consistent with the interpretation of the space as the site of a foreign body around which the sponge grew. The radially arranged polygonal to subcircular apochetes open into the surface grooves and have the same diameter as the grooves. Indeed the grooves appear to represent the lateral coalescence of rows of these apochetes, and many of the surface grooves trail off into a row of separate apopores. Isolated apopores also occur on the polygonal areas between the grooves. Some of these isolated pores are as small as 0.4 mm. The apochetes can be traced for considerable distances within the interior of the sponge, running parallel to the ladder-like series of spicules. They are connected laterally at frequent intervals by slit-like horizontal canals which probably represent surface grooves at an earlier stage of growth. These slits are as wide as the apochetes and as much as 1.8 mm. high. The skeletal pores, outlined by the radial series of dendroclones, are polygonal, with three to five sides, and are 0.2–0.3 mm. in diameter. They continue into the interior between the individual series of spicules. The spicules are typical dendroclones, 0.35–0.55 mm. long and 0.03–0.05 mm. in shaft diameter. The terminal arborescence at one end is usually slightly larger than that at the other, and probably corresponds to the cladome of a normal tetraclone. The rhabdomes are 0.08–0.13 mm. apart vertically (radially) in each ladder-like, radial series. The series are joined laterally in spoke-like fashion, four to six series radiating from a central axis. The interlocking terminal arborescences thus form radial columns which are about 0.18 mm. thick.

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[1] The "*Stuckenbergia* sp." reported by Termier and Termier from the Permian of Tunisia (1955, figs. 8g–i) is certainly not this genus and is probably not an anthaspidellid.

DISCUSSION: It is not clear whether this specimen is complete, or the flat side represents a broken surface. The species has been assigned to *Phacellopegma* Gerth because this is the only described anthaspidellid genus that has a like distribution of pores and deep surface grooves. The present species is closer to the genotype, *P. campanum* Gerth, than to *P. praemorsum* Gerth, which has more weakly developed grooves. The present species differs from the genotype in having somewhat narrower grooves and apopores (0.6–1.6 mm. in *campanum*, compared with 0.4–1.2 mm. in *schizoderma*) and in having longer spicules (0.2 mm. in *campanum* and 0.35–0.55 mm. in *schizoderma*). Because the spicules of *campanum* are shorter, its skeletal pores are correspondingly smaller. This fact, together with the larger size of the apopores, makes for a more pronounced difference in size between the two types of pores than that seen in *schizoderma;* in the former species the skeletal pores are about one-fifth of the size of the apopores, in the latter species they are one-fourth to one-half as large.

MATERIAL: The specimen on which this species was based was collected by Dr. Preston E. Cloud of the United States Geological Survey, who very kindly permitted the writer to describe it in connection with the present study. The well-preserved siliceous specimen had been removed from the limestone matrix with acid.

OCCURRENCE: The specimen was collected at the type locality of the Marble Falls limestone (Pennsylvanian: Atokan) near the base of the formation, about 1 mile south of the bridge over the Colorado River at Marble Falls, on the east side of United States Highway 281, Burnet County, Texas. The enclosing rock is a dark, spiculiferous, somewhat bituminous pure limestone, which closely resembles the basin-facies limestones, such as the Bone Spring, from the west Texas Permian. It is probable that the depositional environment of the Marble Falls limestone was very similar.

HOLOTYPE: U.S.N.M. No. 127599.

MULTISTELLA FINKS, NEW GENUS

DIAGNOSIS: Massive, subspheroidal, with radial architecture; somewhat quadrangular apopores closely apposed in stellate, depressed areas; circular pores of similar size distributed uniformly over the intervening areas; interior canals radial, connected by horizontal canals; basal surface covered with a concentrically wrinkled, imperforate layer.

DISCUSSION: In its spheroidal shape and concentrically rugose base, this genus partakes of a form very characteristic of the family. It is distinguished from other anthaspidellids of similar external form by the concentration of the apopores in sharply delineated clusters of strongly stellate shape. The straightness of the rays of these star-shaped clusters is essentially unique among the anthaspidellids; the similar stellate clusters of *Anthaspidella*, for example, have rather sinuous rays. The distinction between generic and specific characters is essentially arbitrary, but the size and spacing of pores and spicules have been reserved for the specific diagnosis by analogy with other anthaspidellid genera.

GENOTYPE: *Multistella porosa*, new species (lower Guadalupian; Texas). This is the sole species.

OCCURRENCE: Guadalupian; Texas.

Multistella porosa Finks, new species

Plate 9, figures 1–3; plate 10, figures 3–8

DIAGNOSIS: Stellate pore clusters widely spaced, with generally not more than 10 long, straight rays that continue for a short distance as shallow, meandering, and branching grooves; similar short grooves distributed over the remainder of the smooth surface, generally avoiding the isolated apopores; interior canals circular in cross section; skeletal net relatively dense, with skeletal pores one-sixth to one-third of the size of the apopores.

DESCRIPTION: These sponges are spheroidal to ovoid forms with a smoothly convex upper surface which overhangs a concentrically wrinkled, imperforate base. The maximum diameters range from 50 to 70 mm. The holotype, unlike the others, has a conical base, so that the sponge is rather fungiform. The upper surface bears sharply defined, stellate clusters of apopores 3.0–15 mm. apart. Each cluster, which may be slightly depressed below the surrounding smooth surface, contains a circular central cluster of a dozen, or fewer, apopores, from which about 10 single rows of apopores radiate, each row containing from three to five pores. The apopores, which are quadrate to subcircular and 0.3–0.6 mm. in diameter, are separated from one another only by a single spicule series. Each radial row may be prolonged for a few millimeters as a shallow surface groove which may bifurcate terminally. The remaining surface of the sponge is covered by circular pores, of the same size as the apopores in the clusters, which are uniformly spaced 0.9–1.5 mm. (mostly 1.2 mm.) apart. Between them are the polygonal to circular skeletal pores 0.05–0.20 mm. in diameter. The spicules are typical dendroclones 0.18–0.33 mm. long and 0.025–0.050 mm. in shaft diameter. The terminal arborescences are mostly subequal in diameter (0.13–0.20 mm.), but in some spicules one end is broader than the other. They are arranged in the typical radial, ladder-like series, originating at the base of the sponge, with the rhabdomes spaced 0.06–0.17 mm. apart. From five to seven of these series radiate in spoke-like fashion about a central axis. The resulting radial columns formed by the interlocking ends of the spicules project as spherical bumps, 0.1–0.2 mm. in diameter, at the surface. The large surface pores, as well as the skeletal pores, lead into radial canals of the same diameter. The larger canals are connected at intervals by horizontal canals of the same width but often vertically elongate as much as 0.6 mm. or so.

BIOLOGICAL OBSERVATIONS: Most of the specimens show no trace of attachment and may have been buried in the soft sediment up to the limit of the imperforate basal layer. One of the specimens (pl. 10, figs. 7 and 8) began its growth about the beak of a plicate brachiopod shell which it completely surrounded, subsequently developing a concentrically rugose, imperforate base, exterior to the shell.

DISCUSSION: This species can be distinguished from externally similar, smooth-surfaced chiastoclonellids by its highly regular and typically anthaspidellid skeletal net and by its sharply defined, straight-rayed, star-shaped pore clusters. It is the only anthaspidellid so far known from the west Texas Permian. None of the Timor Permian anthaspidellids closely resembles it. The occurrence of this species is restricted to the Getaway limestone of the Guadalupe Mountains.

MATERIAL: Three silicified and acid-prepared specimens were available.

OCCURRENCE: *Horizon:* Guadalupian (Getaway limestone member of Cherry Canyon formation). *Localities:* A.M.N.H. 21SW, 512 (Guadalupe Mountains). *Biotope:* Mixed basin and patch-reef facies. *Lithotope:* Dark, spiculiferous, bituminous limestone.

TYPES: Holotype, U.S.N.M. No. 127600 (from A.M.N.H. 512); paratypes, A.M.N.H. Nos. 28089, 28089:1.

FAMILY **CHIASTOCLONELLIDAE** RAUFF, 1895

Chiastoclonellidae RAUFF, 1895, p. 243. DE LAUBENFELS, 1955, p. E63 (in part).

DIAGNOSIS: Massive sponges with variably developed radial architecture; skeleton consists of chiastoclones, together with dendroclones and tetraclones, not strongly organized in linear series; no dermal specialization other than imperforate basal layer, which is often concentrically rugose.

DISCUSSION: The genera of this family are separated chiefly on the basis of the shape and arrangement of the pores and canals. Only one genus, the Silurian *Chiastoclonella*, was included in the family at the time of its founding. The three Permian genera of the present study are the only others here assigned to it. De Laubenfels (1955, p. E63) included four genera which the writer believes are related to the astylospongiids; they are discussed below under the suborder Eutaxicladina. The chiastoclonellids are very similar to the anthaspidellids in their gross morphology, and Rauff recognized this relationship by grouping the two in his subtribe Orchocladinae, a subdivision of the Tetracladina. The Chiastoclonellidae are differentiated from the Anthaspidellidae by the predominance of chiastoclone spicules over dendroclones and tetraclones and by the fact that the spicules are only obscurely, if at all, arranged in radial series. Typical chiastoclones are spicules in which three long clads, bearing terminal arborescences, radiate from each end of a very short rhabdome. The spicule is consequently somewhat X-shaped in side view, and may be thought of as a dendroclone in which the usual rhabdome has been replaced by a second cladome, or, alternatively, as a dendroclone in which the rhabd has been much shortened and the terminal arborescences strongly developed. It seems reasonably clear that both dendroclones and chiastoclones are modifications of typical tetraclones, and all three types occur in both the Anthaspidellidae and the Chiastoclonellidae. Two other genera were described by Rauff (1895) from the same middle Silurian (Brownsport) beds of Tennessee that yielded *Chiastoclonella*, which resemble that genus in general form. These are *Pycnopegma* Rauff and *Anomoclonella* Rauff. They were placed by Rauff in the Anomocladina of Zittel, a suborder of the lithistids characterized by various sorts of irregular spicules, called by Rauff "ennomoclones." The chief consistency of form shown by these spicules is the presence of one or two spherical nodes, from each of which more than three large clads radiate. The terminology applied to these spicules by various authors has not been consistent. Those forms in which clads radiate in all directions from a single node have been called "sphaeroclones." If the clads were confined to one side of the node, Rauff used the term "anomoclone." However, similar spicules have also been called "dicranoclones." In the writer's opinion, those "dicranoclones" in which but three rays diverge from the centrum of the spicule, and which are clearly derivable from a normal tetraclad form such as those characteristic of the eutaxicladine families Hindiidae and Gignouxiidae, should be differentiated from those forms in which more than three clads are present. The latter type is found consistently in the eutaxicladine family Astylospongiidae, as well as to a limited extent in the Silurian genera *Anomoclonella* and *Pycnopegma*, which Rauff assigned to the Anomocladina. This latter suborder was originally established by Zittel for the Jurassic sponges *Cylindrophyma* and *Melonella*, in which the spicules have two spherical nodes at each end of a short rhabd, with more than three clads diverging from each node. This double anomoclone was termed by Rauff a "didymoclone," and also occurs in his two Silurian genera, along with single anomoclones. The didymoclones of the Silurian genera appear, however, to have but three clads at each end, and the form of the spicule is consequently very close to that of a chiastoclone. Because these sponges externally resemble chiastoclonellids and are associated with them, the possibility is suggested that they may be related more closely to the Chiastoclonellidae than to the Jurassic anomocladines. The presence of a single anomoclone with more than three clads would then represent an independent development. The family Cylindrophymatidae was established by Schrammen (1936) for Zittel's two Jurassic forms plus three other Jurassic genera. Rauff (1895) had already established the family Anomoclonellidae for the Silurian species. It may be that the family Anomoclonellidae should be removed to the suborder Tetracladina, at least until a more satisfactory method of subdividing the Order Lithistida has been found.

Of the Permian genera here included, *Insulipora* is most clearly a chiastoclonellid in the original sense of Rauff, for the majority of its spicules are typical chiastoclones. *Defordia* has the typical gross morphology of the anthaspidellid-chiastoclonellid stock, with its radial canal system and concentrically wrinkled base, but chiastoclones are seemingly subordinate in number to normal tetraclones. *Actinocoelia* is least typical of the family in its general morphology but still shows a radiate architecture and seems to possess a few chiastoclones.

INCLUDED GENERA: *Chiastoclonella* Rauff, 1895 (Silurian); *Insulipora*, new genus (Permian); *Defordia* R. H. King, 1943 (Permian); *Actinocoelia*, new genus (Permian).

OCCURRENCE: Silurian (Tennessee); Permian (Texas, New Mexico, Utah, Arizona, Nevada).

INSULIPORA FINKS, NEW GENUS

DIAGNOSIS: Massive, with concentrically wrinkled, possibly imperforate, basal dermal layer; surface bearing circular oscular depressions, isolated circular ostia, and meandering, anastomosing grooves which generally avoid the ostia; interior canals irregularly oriented and anastomosing.

DISCUSSION: The single species assigned to this genus superficially resembles a smooth-surfaced *Defordia* but differs in that the very regularly spaced small ostia are not connected by the surface grooves but are rather surrounded by them, so that each ostium is at the center of a polygonal area outlined by the grooves. It also seemingly differs in that true chiastoclones form a larger, and possibly major, proportion of the spicules. There is little doubt that this genus and species fall within the concept of the family Chiastoclonellidae as originally established by Rauff. The distinctions made herein between generic and specific characters in the diagnoses are of necessity arbitrary, but they have been modeled on the equivalent characters of other genera in the family.

GENOTYPE: *Insulipora elegans*, new species. This is the sole species.

OCCURRENCE: Leonardian; Texas.

Insulipora elegans Finks, new species

Plate 11, figures 2–10; plate 12, figures 1, 2

DIAGNOSIS: Spheroidal, ovoid, or bun-shaped, with smooth upper surface; oscular depressions widely spaced; small ostia closely and uniformly spaced; surface grooves numerous, often completely surrounding each large pore and converging on, but not connecting with, the oscular depressions; skeleton dense; interior canals widely spaced and having the diameter of the large pores.

DESCRIPTION: The adult specimens of this species are vertically flattened ovoid sponges 40–50 mm. in maximum lateral dimension and 25–30 mm. high. The basal surface is concentrically wrinkled and somewhat overhung by the upper surface; it is not imperforate, but the surface may not be completely preserved. The upper surface is convex and smoothly rounded. It bears uniformly spaced circular ostia 0.3–0.5 mm. in diameter and spaced 0.8–1.8 mm. apart. Between them are anastomosing surface canals of the same width. The canals are most prominent near the oscules or apopore clusters, towards which they converge. Where the canals are well developed, each ostium is completely surrounded by canals, and it occupies the center of a polygonal area about 1.8 mm. in diameter. The apopores are organized into clusters located in sharply depressed circular areas 1.5–3.5 mm. in diameter. The apopores themselves range from 0.5 to 1.2 mm. in diameter, and generally a large apopore is located in the center of the cluster, with a single ring of smaller apopores about it. In many cases the cluster is so strongly depressed that it appears to open as a single large oscule on the surface. The skeletal pores are 0.05–0.20 mm. in diameter. The interior is occupied by a dense skeletal net with sparsely distributed canals the diameter of the ostia. Some are radial and are connected with the ostia; others are more or less horizontal and probably represent former surface grooves, still others have an oblique orientation and may be apochetes which are convergent upon the apopore clusters. The spicules show no clear arrangement in radial rows. The majority of the spicules visible in thin sections (see pl. 12, figs. 1 and 2) are X-shaped chiastoclones, with two or three long clads diverging from each end of an extremely short rhabd. The spicules isolated from the skeletal net at the surface were more often normal tetraclones. In some of them the rhabdome was no longer than the three clads. Dendroclones were also isolated, as well as a few curving, possibly monocrepid, spicules bearing arborescences along the convex side. These probably outline pores or canals and are similar to spicules seen in equivalent situations in the anthracosyconids. The spicules range in length from 0.15 to 0.33 mm. and the rhabdomes are about 0.05 mm. thick.

A possible juvenile of this species was obtained from U.S.N.M. 705a (see pl. 11, fig. 2). It is ovoid and 10 mm. in length and grew around a slender cylindrical object. It shows no oscule, but the arrangement of ostia and surface canals is similar to that of the type specimens.

Discussion: Because the genus is monobasic, it is difficult to determine which characters are specific and which generic. Those selected for the diagnosis were chosen by analogy with other chiastoclonellid specific characters. This form occurs with species of *Defordia*, from which it can be distinguished by the generic characters as well as by the presumably specific character that its ostia and surface grooves are finer than in any of the species of *Defordia*.

Material: Three silicified specimens were studied from the type locality. One juvenile was recognized from another locality.

Occurrence: *Horizon:* Leonardian. *Localities:* U.S.N.M. 705a, 707q (Glass Mountains). *Biotopes:* Mixed basin and patch-reef facies; shelf facies. *Lithotopes:* Highly argillaceous limestone; light limestone.

Types: Holotype, U.S.N.M. No. 127601 (from U.S.N.M. 707q); paratypes, U.S.N.M. Nos. 127602, 127603.

Genus **DEFORDIA** R. H. King, 1943

Defordia R. H. King, 1943, p. 16.

Diagnosis: Massive, with concentrically wrinkled, imperforate, basal dermal layer; upper surface bearing oscules, more or less uniformly distributed large pores (ostia), skeletal pores, and shallow to deep grooves which connect with each of the large pores and converge towards the oscules; interior canals radial and concentric.

Discussion: The species of this genus are separated chiefly on the basis of: (1) body form, and (2) the number, size, and distribution of the pores and canals. These differences are of the sort that may be determined by environmental conditions, and the question exists whether any or all of the recognized species are truly genetically distinct populations. In general each of the species is geographically restricted, and the characters are consistent within the group. In the case of the two species for which the largest samples are available, namely, *defuncta* and *densa*, each shows a few variant individuals that approach the form of the other, but the bulk of the two populations can be readily separated one from another. Whether these two populations are genetically distinct or not, there is a strong possibility that their differences reflect differences in the environment, as well as the effects of geographic separation, for *densa* occurs chiefly in the basin facies, whereas *defuncta* occurs in the shelf or patch-reef biotopes. The specimen of *densa* that is closest in form to *defuncta* is from the shelf-facies Victorio Peak formation, although other individuals from this formation are much more typical of the species. This fact suggests that both genetic and environmental effects may be involved. *Defordia lobata*, which is closer in form to *densa* than to *defuncta*, is, as are most specimens of *densa*, from a basin assemblage. *Defordia* sp. cf. *densa* is from a mixed basin and patch-reef fauna, as is *Defordia* sp. This genus has been assigned to the family Chiastoclonellidae because of its generally radiate architecture, its possession of a strong, concentrically wrinkled, basal, imperforate dermal layer, and especially because of the occurrence of some chiastoclones and dendroclones among the spicules. The chiastoclones and dendroclones, however, are distinctly subordinate in number to normal tetraclones. De Laubenfels (1955, p. E53) assigned *Defordia* tentatively to the Aulocopiidae, equivalent to the Anthaspidellidae of the present paper, but it cannot be assigned to that family as here understood.

GENOTYPE: *Defordia defuncta* R. H. King, 1943.

INCLUDED SPECIES: *Defordia defuncta* R. H. King, 1943 (Glass Mountains); *D. densa*, new species (Sierra Diablo); *D.* sp. cf. *D. densa* (Glass Mountains); *D. lobata*, new species (Glass Mountains); *Defordia* sp. (Glass Mountains).

OCCURRENCE: Leonardian; Texas. (A possible member of this genus, not described in this paper, is known from a single specimen from the Wolfcampian Hueco limestone at U.S.N.M. 712e in New Mexico.)

Defordia defuncta R. H. King, 1943

Plate 12, figures 3–6; plate 13, figures 1–9; text figures 8–20

Defordia defuncta R. H. KING, 1943, p. 17, pl. 1, fig. 7, pl. 2, fig. 9, pl. 3, fig. 9.

DIAGNOSIS: Spheroidal to bun-shaped; upper surface covered by small, closely spaced, equidimensional, flat-topped projections outlined by deep grooves; oscules variable in number, each one the opening of a shallow depression, often at the summit of a low, rounded eminence; interior containing anastomosing cavernous spaces, as well as canals the size of the large pores, both with a poorly defined radial and concentric arrangement; apochetes converging towards oscular depressions; intervening areas occupied by dense spicular net.

DESCRIPTION: These are medium to large spheroidal sponges 40–170 mm. in diameter which have a somewhat flattened base, covered with a smooth, imperforate, dermal layer, which bears coarse concentric wrinkles, 5 mm. or so in width. The wrinkles are produced by the tendency for the upper surface to overhang the basal layer as the sponge grows. The whole upper surface is rough, being covered by a close net of deep anastomosing surface grooves 0.3–1.3 mm. wide, which separate more or less equidimensional flat-topped areas 1–3 mm. in diameter. The upper surface is further thrown into low projecting areas 10–15 mm. wide around each of the oscules. These protuberances may coalesce into meandriform rows separated by elongate depressed areas of the same width. The circular oscules are 1.8–3.6 mm. in diameter. Some oscules split into two to four smaller apopores just below the surface. The ostia, 0.4–1.2 mm. in diameter and spaced 0.9–1.8 mm. apart, are located chiefly in the floors of the surface grooves. The skeletal pores, which are present everywhere except on the base, are 0.05–0.40 mm. in diameter. The interior contains canals of the same range in size as the ostia. Those that have a radial orientation and connect with the ostia directly are probably prosochetes. Similar concentric ones probably correspond to former surface grooves. Some interior canals are convergent towards the oscules and are clearly apochetes. In addition to these smaller canals there are larger, irregular, anastomosing, cavernous spaces which tend to be elongate radially. They may correspond in origin to the depressions on the upper surface between the oscular mounds. The spicules show no consistent orientation in the skeletal net. Most of them are normal tetraclones with a short, thick, smooth rhabdome, 0.20–0.25 mm. long and 0.05 mm. in diameter. Three large, smooth-shafted clads at one end of the spicule are nearly as long as the rhabdome but are thinner. They end in delicately branched arborescences, and the whole cladome is 0.2–0.3 mm. wide. The opposite end of the rhabdome bears similar terminal arborescences, but the ensemble is not so wide as the cladome. Some of the spicules resemble dendroclones, because the cladome is reduced in width so that the arborescent processes at each end of the rhabd are equal in size. Other spicules resemble chiastoclones, having an extremely short rhabdome with large clads at both ends.

BIOLOGICAL OBSERVATIONS: Very few of the great number of specimens of this species give any indication of attachment to a hard object on the substratum. One individual is basally attached to a brachiopod shell fragment, possibly the sessile brachiopod *Prorichthofenia*, two are attached to heavy pelecypod shell fragments, and two overgrew rugose and auloporoid corals. One unusual specimen completely surrounds a large crinoid stem, 10 mm. in diameter, which passes through the specimen from one end to the other. This sponge shows no trace of an imperforate basal layer, and it may have been supported completely above the sea floor by the rooted stem of the living crinoid. All the other sponges may well have been sunk in the soft lime mud as far as the upper limit of the imperforate basal surface. Some specimens show evidences of epoecious organisms that grew on the sponge while it was alive. The individual shown in plate 12, figure 6, bears two molds of conularids, probably *Conularia leonardensis* Finks, sunk perpendicularly into the upper surface of the sponge. This species of conularid has been found in similar positions on other species of sponges (see below under *Haplistion aeluroglossa*, and also Finks, 1955) and possibly was habitually symbiotic with sponges. Another specimen has the upper surface nearly covered with an encrusting bryozoan, which is absent about some of the oscules. This may indicate that the sponge was still alive when overgrown, though such cannot be demonstrated conclusively. Two specimens have overgrown auloporoid corals that had settled on their upper surfaces.

Several small, poorly preserved specimens have been found at the type locality which are probably juveniles of this species (see pl. 13, figs. 1–5). In general they show the same characters as the adults, but their shape is more variable, and in some the base is distinctly pedunculate.

DISCUSSION: The chief characters that separate this species from the others in the genus are the strongly convex upper surface, the strong development of surface grooves, the presence of irregular cavernous spaces in the interior, and the strong development of a broad, imperforate, basal surface. The degree to which the surface grooves are incised and the oscular protuberances are developed is highly variable, even at the same locality, but in general the surface grooves are more prominent than in the other species. This species is extremely abundant at certain localities in the Leonard formation of the Glass Mountains, especially at the type locality, which is in the Hess facies of the Leonard ("Hess sponge bed"). It does not appear to be present in the Sierra Diablo, where it is replaced by *Defordia densa*, in beds of equivalent age.

MATERIAL: About 100 specimens were available for study from the type locality, including the holotype and the paratypes as well as 30 individuals from other localities. All are silicified.

OCCURRENCE: *Horizon:* Leonardian. *Localities:* U.S.N.M. 702, 702b, 703b, 705a (Glass Mountains). *Biotopes:* Shelf facies (Hess); patch-reef facies. *Lithotopes:* Dolomitic limestone (Hess facies); light, bioclastic limestone.

TYPES: Holotype, A.M.N.H. No. 25229 (from approximately U.S.N.M. 705a); paratypes, A.M.N.H. Nos. 25230, 25231; illustrated hypotypes, U.S.N.M. Nos. 127604a–127604m (these are topotypes).

Defordia densa Finks, new species

Plate 14, figures 3–6, 10; text figures 21–26

DIAGNOSIS: Spheroidal to flattened-lobate or subdigitate; surface grooves very shallow, most prominent near oscules; oscular depressions shallow or replaced by a circular cluster of apopores; interior canals connected with the large pores radially arranged, apochetes converging obliquely towards oscular depressions; interior dense, without cavernous spaces.

DESCRIPTION: These are medium to large sponges, 50–180 mm. in maximum dimensions, the form of which varies from nearly spherical to very flattened and lobate, on the one hand, and to subdigitate on the other. The base invariably bears an imperforate dermal layer, which is overhung by the upper surface, and is concentrically wrinkled about the growing point, which is often a shell or bryozoan. The surface is covered with circular ostia 0.3–0.9 mm. in diameter and spaced 0.6–2.4 mm. apart. The range of size variation is usually less on a single individual than the total range given above. The ostia tend to be connected by surface grooves of the same size, but on most specimens they are obscure. They are deepest on the subdigitate forms. Similar grooves often radiate from the oscules, which are circular to elliptical and are 1.2–2.5 mm. in diameter and spaced 5–20 mm. apart. The oscules are flush with the surface on most specimens but are bounded by a low, raised rim on some. The remainder of the surface, except for the imperforate base, bears skeletal pores 0.025–0.20 mm. in diameter. The interior contains numerous radial canals leading to the ostia. There are also horizontal connecting canals which probably correspond to the former surface grooves. No canals the size of the oscules are present, and the oscules appear to break up below the surface into divergent canals (apochetes) the size of the radial canals. The skeleton is a very dense net of randomly arranged spicules of essentially the same size and form as those of *Defordia defuncta*.

BIOLOGICAL OBSERVATIONS: Several specimens, such as the one illustrated in plate 14, figure 3, have cavities of lenticular cross section embedded in the surface and lined with an imperforate layer. Probably these are the sites of some epoecious organism, possibly a cirripede (M. K. Elias, personal communication). They are similar to borings found in many gastropod and brachiopod shells from the Texas Permian, such as the platyceratids illustrated in Yochelson (1956, pl. 23, figs. 24–26). Other specimens bear large, funnel-shaped depressions on the surface, lined with an imperforate layer (see pl. 14, fig. 10), which probably also represent the attachment sites of a foreign organism. The holotype (pl. 14, fig. 5) has partly overgrown a massive bryozoan colony which grew on part of its upper surface, thus establishing the fact that both organisms were alive simultaneously.

DISCUSSION: This species is highly variable in shape and the prominence of its surface canals. However, all the specimens differ from *Defordia defuncta* in the relative smoothness of the upper surface and in the absence of cavernous spaces on the interior. None of the specimens has the nearly equidimensional fungiform shape characteristic of *defuncta*. Those specimens that have a broad, concentrically rugose basal surface are much flattened vertically and have a relatively flat upper surface, rather than the highly convex form characteristic of *defuncta*. *Defordia lobata* differs from the present species in having fewer ostia, oscules, and surface canals. This species is essentially confined to the Leonardian of the Sierra Diablo. It is replaced by *Defordia defuncta* in the equivalent beds of the Glass Mountains. One or two individuals of *Defordia defuncta* at its type locality (see pl. 13, fig. 8) approach *densa* in the relative smoothness of the surface, but these variants constitute an extremely small minority. Possibly the two species are merely different ecophenotypes, rather than genetically distinct populations, but the general consistency of the differences between the populations of the two areas favors the recognition of separate species.

MATERIAL: Nearly 100 silicified whole individuals and fragments were available for study. Most are from localities in the basin facies of the Bone Spring limestone in the Sierra Diablo.

OCCURRENCE: *Horizon:* Leonardian. *Localities:* P.U. 1r, 1rc, 2, 10x, 16x, 20f, 20h, 20i, 54d, 77, 83t, 84t; U.S.G.S. 7055a, 14444, 14467, 14470. *Biotopes:* Basin facies; shelf facies. *Lithotopes:* Dark, bituminous, spiculiferous limestone; light, bioclastic limestone.

TYPES: Holotype, P.U. No. 78867 (from P.U. 1rc); illustrated paratypes, P.U. Nos. 78868, 78871, 78889, U.S.N.M. 127606.

Defordia sp. cf. **Defordia densa**

Plate 14, figures 7–9; text figures 27–30

DESCRIPTION: These are bun-shaped sponges with a flat or slightly convex upper surface. They range in height from 25 mm. to 40 mm. and in diameter from 40 mm. to 95 mm. An imperforate layer may be developed on part of the basal surface, apparently in all cases where the sponge was in contact with a shell on the substratum. The upper surface is covered with large pores 0.3–1.8 mm. in diameter, the larger ones presumably corresponding to oscules. Poorly developed but closely spaced surface canals cover most of the upper surface. The skeletal pores are mostly 0.05–0.15 mm. in diameter. The interior contains canals perpendicular to the upper surface and the same diameter as the large pores. The skeleton is a dense net of irregularly arranged desmas like those of the other species of *Defordia*.

DISCUSSION: These forms seem to belong to the *Defordia* complex and are closer to *D. densa* than to any of the other named species. The lobate sponge described below as *Defordia* species occurs at the same locality. Possibly they belong to a single species, but the present forms are not lobate and have more numerous large pores.

MATERIAL AND OCCURRENCE: Three silicified, acid-prepared specimens were studied.

They are from U.S.N.M. 707q, a basin facies locality in the Leonard formation of the Glass Mountains. It is here a highly argillaceous limestone. The illustrated specimen is U.S.N.M. No. 127607a.

Defordia lobata Finks, new species

Plate 15, figures 5–12

DIAGNOSIS: Spheroidal to massive and lobate; basal dermal layer reduced or absent; surface divided into low, rounded lobes by sulci lined with imperforate dermal layer; surface grooves weakly developed; oscules few or absent; large pores irregularly distributed and variable in size; interior dense, with narrow canals; small cavernous spaces may be present.

DESCRIPTION: The smaller specimens of this species are smoothly rounded spheroidal or ovoid specimens, but most show a definite tendency to form poorly defined lobes, 10–25 mm. across and separated by broad, shallow grooves or sulci, 2–10 mm. wide. The specimens range in maximum diameter from 7.0 mm. to 70 mm. The holotype is the largest specimen. The larger specimens are distinctly flattened. When the sulci are well developed they are lined with an imperforate dermal layer. Some of these may have been originally molded to objects on the substratum, but they were invariably filled, on the specimens studied, with loose spicular debris belonging to the enclosing sediment. A similar imperforate layer is present on one side of a lobe of the holotype and is concentrically wrinkled as in the other species of *Defordia.* The rest of the surface is quite smooth and bears, in addition to the skeletal pores 0.05–0.13 mm. in diameter, larger circular ostia 0.2–1.0 mm. in diameter and spaced 0.8–3.0 mm. apart. Short surface grooves of the same diameter may connect a few of these ostia, but they are not well developed. A single circular oscule 2.2 mm. in diameter is present on one lobe of the holotype, but none is present on the smaller specimens. The interior bears radial and horizontal canals of the same diameter and spacing as the large surface pores. In general the interior is quite dense, but some fragments show anastomosing cavernous spaces, as much as 2.4 mm. in diameter, which have a predominantly radial arrangement. The skeletal net consists of tetraclones 0.13–0.25 mm. long and 0.03–0.05 mm. in shaft diameter, which seem to be arranged irregularly. Individual spicules could not be isolated.

DISCUSSION: This species is characterized by the paucity of its surface grooves and oscules, as well as by its tendency to develop a lobate form. It is closer to *Defordia densa* in general appearance than to *D. defuncta. Defordia* sp. at U.S.N.M. 707q somewhat resembles the present species in its lobate form but possesses well-developed surface grooves and more numerous oscules.

MATERIAL: Nine fairly complete specimens were available from the single locality, as well as numerous fragments, many of which were pebble-like and apparently abraded by current action.

OCCURRENCE: *Horizon:* Upper Wolfcampian or lower Leonardian. *Locality:* U.S.N.M. 707ha (Glass Mountains). *Biotope:* Basin facies. *Lithotope:* Dark, spiculiferous limestone.

TYPES: Holotype, U.S.N.M. No. 127608; paratypes, U.S.N. M. Nos. 127609a,–127609b.

Defordia species

Plate 15, figures 1–4; text figures 31–35

DESCRIPTION: The single specimen is a flattened-spheroidal, irregularly lobate sponge, 70 mm. in maximum diameter and 45 mm. thick. There are no clearly defined upper and lower surfaces. The subglobular lobes are 15–30 mm. wide and are separated by poorly defined sulci about 4–7 mm. wide. The whole surface is covered with anastomosing canals 0.4–0.8 mm. wide which divide the surface into flat-topped polygonal areas 1.8–3.6 mm. in diameter. Circular ostia, 0.3–0.7 mm. in diameter, are scattered irregularly and sparsely over the surface, both in the grooves and over the intervening areas. There may be more of them in the grooves than are apparent, because the grooves are largely filled with fine clay matrix. The skeletal pores are 0.03–0.15 mm. in diameter, and a few pores are present which are intermediate in size between these and the ostia. Circular oscules, 1–2 mm. in diameter, are present at the intersections of some of the surface grooves. The internal canal system was not observed. The skeleton is a dense net of irregularly arranged tetraclones, some of which approach the form of dendroclones and possibly of chiastoclones. The spicules are 0.15–0.30 mm. long, their rhabdomes 0.025–0.050 mm. thick, and their cladomes 0.10–0.20 mm. wide.

DISCUSSION: This species differs from the other members of the genus in the strong development of surface grooves accompanying a relatively smooth surface. The lobate form is like that of *D. lobata*, from which it is distinguished, in addition to the characters mentioned above, by its more numerous oscules and by the smaller size of its ostia.

MATERIAL AND OCCURRENCE: The single silicified and acid-prepared specimen, U.S.N.M. No. 127610, was obtained from U.S.N.M. 707q in the Glass Mountains which represents a Leonardian basin and patch-reef facies biotope and a highly argillaceous limestone lithotope.

ACTINOCOELIA FINKS, NEW GENUS

DIAGNOSIS: Massive, with radial architecture; skeletal net dense but separated by canal system into continuous radial trabeculae connected at right angles by similar trabeculae; ends of radial trabeculae projecting strongly above surface; radial canals long and continuous, connected by horizontal canals corresponding to meandriform, anastomosing grooves at surface; large oscules present; imperforate basal layer may be developed.

DISCUSSION: The two species assigned here are separated chiefly on the basis of: (1) body form, (2) surface ornamentation, and (3) the shape, size, and spacing of the pores and canals. The species *verrucosa*, which is contemporary with the genotype but allopatric, is placed here only tentatively. It has an external form similar to that of the genotype and shows in sagittal section the same strongly radial arrangement of canals and intervening trabeculae, but it possesses peculiarities such as the presence of smooth monaxons and the organization of the apopores in clusters, which are characters commonly significant at the generic level. The specimens are too poorly preserved, however, to permit the establishment of an adequate differential generic diagnosis, and the species has been retained in the present genus.

Whether or not the two species belong to separate genera, they both seem to be related to the other chiastoclonellids of the present collection, especially to *Defordia*. The general architecture of the body, particularly the canal system, is the same, and the spicules are nearly identical in form and size. Chiastoclones appear to be distinctly subordinate to regular tetraclones in the present genus. The very cavernous nature of the genotype should probably be considered a generic feature. It differs from the frequently cavernous *Defordia defuncta* in the elongate form and strongly radial arrangement of the spaces. The calcareous alga *Somphospongia* Beede superficially resembles the spheroidal specimens of this genus. The surface grooves of the alga, however, do not anastomose so completely as those of the sponge, and of course the presence of spicules in *Actinocoelia* is a positive means of identification.

GENOTYPE: *Actinocoelia maeandrina* Finks, new species (upper Leonardian, lower Guadalupian).

INCLUDED SPECIES: *Actinocoelia maeandrina* Finks, new species; ?*A. verrucosa* Finks, new species.

OCCURRENCE: Upper Leonardian (Texas, Arizona, Utah, Nevada); lower Guadalupian (New Mexico).

Actinocoelia maeandrina Finks, new species

Plate 16, figures 4–9; plate 17, figures 1, 2; plate 19, figures 8–10; text figures 36–38

Sponge MCKEE, 1938, p. 155, pl. 24, fig. a.

DIAGNOSIS: Compressed spheroidal to cylindrical, the center of radiation at one end; trabeculae thin, laterally compressed, frequently curved and laterally anastomosing, the radial elements ending at the surface as flat-topped projections; radial canals the same diameter as trabeculae, circular to elliptical in cross section and frequently confluent laterally; surface grooves and corresponding interior canals deep and slit-like; oscules large, circular, and opening into deep radial spaces of similar diameter; imperforate dermal layer weakly developed, if at all.

DESCRIPTION: The holotype is a large, laterally compressed, spheroidal individual, 100 mm. in diameter and 50 mm. thick. On the narrow upper edge there are four circular oscules 5–9 mm. in diameter, which are the openings of radial apochetes of the same size. The whole sponge is very cavernous, resembling a common bath sponge, and it is filled with radial anastomosing canals. These reduce the sponge tissue to radial trabeculae that anastomose laterally and are also connected by horizontal trabeculae. The radial canals have basically a circular cross section 0.7–2.4 mm. in diameter and open on the surface with pores of this size. However, several adjacent canals are frequently connected laterally in meandriform rows, so that the surface of the sponge bears corresponding deep meandriform grooves. The intervening trabeculae are 0.5–2.4 mm. thick, and, where the radial spaces are laterally confluent, the trabeculae form wall-like structures. Elsewhere, the radial trabeculae are connected by lath-like cross trabeculae, 0.4–1.2 mm. thick and 1–3 mm. high, separated vertically by spaces 1–6 mm. high. The outer ends of the radial trabeculae are sharp and irregular, so that the surface of the sponge is rough. The center of radiation is near the basal end. The skeleton is a dense net of irregularly arranged desmas, mostly smooth-shafted tetraclones with strong terminal arborescences. Some resemble short dendroclones, and chiastoclone types may possibly be present. The spicules are 0.2–0.3 mm. long, the cladomes 0.2 mm. wide, and the rhabdomes 0.05 mm. thick. The skeletal pores are 0.05–0.20 mm. in diameter. Patches of the sponge surface are smooth and nearly imperforate, apparently representing places where the sponge was in contact with other objects. A small, incomplete, cylindrical individual of this species, 7 mm. in diameter, is adherent to one side of the specimen and is partly surrounded by the larger sponge.

At other localities both compressed spheroidal individuals and elongate cylindrical individuals occur. The spheroidal forms range in diameter from 45 to 150 mm. The cylindrical ones range in diameter from 7 to 30 mm. In the latter types the trabeculae and canals radiate upward and outward from the basal end of the sponge. No large oscules have been seen on any of these forms, but the dimensions of the other elements are essentially the same as those of the holotype described above.

Stratigraphic Observations: This species is very common in the Victorio Peak limestone of the Sierra Diablo in west Texas, as well as in the beta-member, facies 1, of the Kaibab formation in northwestern Arizona and adjacent parts of Utah and Nevada. The Kaibab formation has been correlated by McKee with the upper Leonard on the basis of its brachiopod fauna as well as on stratigraphic evidence (see McKee, 1938, p. 171). As the Victorio Peak formation is also correlated with the upper Leonard on both paleontologic and stratigraphic grounds, the presence of *Actinocoelia maeandrina* in both the Victorio Peak and the Kaibab formations may be considered as additional evidence of their approximate contemporaneity. The environments of the two areas seem to have been very similar. The Victorio Peak limestone represents a shallow-water, normal, marine, shelf environment (see Newell and others, 1953, p. 21). McKee (1938, pp. 45 ff., 142) interprets his facies 1 of the beta-member of the Kaibab as having been laid down also in shallow water under normal marine conditions. The type locality of this species, U.S.N.M. 749, is in the vicinity of Queen, New Mexico, well to the north of the Sierra Diablo. Its horizon was identified as the San Andres formation by the collector (C. C. Branson) which places this at a higher stratigraphic level than the other occurrences of the species, being equivalent to the lowermost Guadulupian. The environment of this locality was presumably also a shelf area, possibly nearer to the shore line than the others.

One of the occurrences of this species is apparently in the basin facies of the Bone Spring formation (U.S.G.S. 5777), and two others (P.U. 20f and 20gh), although probably from the basal beds of the Victorio Peak limestone, may be from the immediately underlying basin facies limestones. Possibly this species also lived in the basin environment, but the specimens may also have been washed in from surrounding shelf areas.

The geographic distribution of this species is noteworthy. It is confined to the region to the north and west of the Delaware Basin and is absent from beds of equivalent age and facies in the Glass Mountains. It is replaced in the latter region by *?Actinocoelia verrucosa.* This suggests that the deep waters of the Delaware Basin may have acted as a barrier to the dispersal of *A. maeandrina.* It also suggests that the areas of deposition of the Victorio Peak and the Kaibab formations may have had a continuous connection of shelf sea. As the beta-member of the Kaibab passes eastward into near-shore facies well short of the Arizona-New Mexico line (see McKee, 1938, p. 149), and the Victorio Peak does likewise in a northwestward direction from the Sierra Diablo-Guadalupe Mountains area (see Newell and others, 1953, p. 21), there must have been an intervening land area or areas in western New Mexico and eastern Arizona. Whether narrow seaways persisted through this region, or the connection was to the south in northern Mexico cannot be demonstrated from the presently available geologic evidence.

DISCUSSION: Most of the specimens of this species are flattened, which is probably a consequence of post-burial compaction of the very cavernous sponge. In poorly preserved cross sections it is sometimes difficult to distinguish this species from *?A. verrucosa*, for both show the same large radial trabeculae. *Actinocoelia maeandrina*, however, has thinner trabeculae and wider canals. Where the outer surface is preserved, *verrucosa* can be identified by the characteristic conical protuberances, by the presence of apopore clusters, and by the lack of deep, meandriform, surface canals. Some cylindrical specimens of *A. maeandrina* resemble *Jereina cylindrica* in cross section but can be distinguished by the absence of a dense outer rind and by the more pervasive and more strongly developed surface grooves.

The specimens from the Kaibab formation cited by McKee were not studied by the present writer. However, the specimen illustrated by McKee (1938, pl. 24a) is almost certainly this species, and the writer has seen a specimen from the Kaibab formation in the collections of the United States National Museum which clearly belongs to this species.[1]

At P.U. 80c, which is a basin-facies locality in the basal Bone Spring limestone of the Sierra Diablo, there are four poorly preserved sponges that may belong to this species. The largest is illustrated as specimen D on plate 19, figures 8–10. They are too poorly preserved to be identified with certainty.

MATERIAL: Thirty silicified specimens were available for study. All were from various localities in the Victorio Peak limestone of the Sierra Diablo, except for two from the type locality (San Andres formation), two from the Kaibab formation of the Grand Canyon region, and one from the Bone Spring limestone.

OCCURRENCE: *Horizons:* Upper Leonardian (Victorio Peak and Kaibab formation), lower Guadalupian (San Andres formation). *Localities:* P.U. 20f, 20gh, 29, 32, 53g[2]; U.S.G.S. 5777, 7011, 14444, 14470 (Sierra Diablo); U.S.N.M. 749 (Guadalupe Mountains); Kaibab formation (beta-member) of Grand Canyon region. *Biotopes:* Shelf facies; basin facies. *Lithotope:* Light, largely bioclastic limestones.

TYPES: Holotype, U.S.N.M. No. 127611 (from U.S.N.M. 749); paratypes, U.S.N.M. No. 127612, P.U. No. 78882.

?Actinocoelia verrucosa Finks, new species

Plate 17, figures 3–7; plate 18, figures 1, 2

DIAGNOSIS: Bun-shaped, with well-developed, imperforate basal layer; radial trabeculae stout, much larger than canals, and ending at the surface in conical projections bearing low, radiating ridges; surface grooves broad and shallow, convergent towards oscules; radial canals small and circular in cross section; oscules represented by shallow depressions containing clusters of apopores; radially oriented bundles of parallel, slender monaxons present in at least some of the radial trabeculae.

DESCRIPTION: These sponges are all compressed spheroidal forms 40–150 mm. in diameter. The basal surface on some is smooth and apparently imperforate. The upper surface is covered with conical projections 2–5 mm. in diameter, though the range of size is less on a given specimen. The projections often bear low, radial ridges. These projections are outlined by shallow surface grooves 1–2 mm. in width, which connect circular pores 0.5–2.0 mm. in diameter, spaced 2–4 mm. apart. Pores of similar size are concentrated in several subcircular clusters, about 10 mm. in diameter; the surface grooves in the vicinity of these apopore clusters are more deeply incised than elsewhere and converge towards the clusters. On one specimen (pl. 18, fig. 1) the clusters are replaced by circular oscules of similar dimensions, each surrounded by a raised rim. The skeletal pores are 0.05–0.30 mm. in diameter. The interior of the sponge contains long radial canals of similar diameter to the large pores. They are separated by radial trabeculae corresponding in diameter to the conical projections of the surface. The interiors of all the specimens are chertified, and the skeletal net could not be observed. On the surface the spicules can be seen in certain areas and appear to be smooth-shafted tetraclones about 0.5 mm. long. Some may be chiastoclones or dendroclones. The flattened trabeculae separating the radiating surface grooves in the vicinity of one of the pore clusters on the holotype (see pl. 18, figs. 5, 6) appear to consist of parallel, thin monaxons, covered by a layer of tetraclones.

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[1] Since the above was written, the writer was privileged to examine a collection of sponges from the beta-member of the Kaibab formation lent by Dr. L. F. Brady of the Museum of Northern Arizona. All are referable to *Actinocoelia maeandrina* and abundantly confirm the common occurrence of this species in the Kaibab. At about the same time, Dr. E. L. Yochelson, of the United States Geological Survey, lent a collection of sponges recently obtained from the Park City formation in the Wind River mountains near Dubois, Wyoming (U.S.G.S. 18605, along both sides of fence line in the SW. ¼ sect. 23, T. 41 N., R. 107 W., 3.5 miles by road southwest of Dubois, Wyoming, on ridge northwest of Jakey's Fork). These are the first whole sponges obtained from this formation and occur in great abundance at the locality. They are also all referable to *Actinocoelia maeandrina* and show the same range of growth form as at the other localities. This new occurrence attests to the widespread distribution of *Actinocoelia maeandrina* in the middle Permian shelf seas of the Cordilleran region. The abundance of this sponge in deposits of shelf type, such as the Park City, Kaibab, and Victorio Peak formations, is worth noting.

[2] The specimen is labeled "53g (plateau)"; it was probably collected from the Victorio Peak limestone on the plateau above locality 53g.

DISCUSSION: This species may well represent a new genus, but its skeletal net is too poorly understood to yield an adequate generic diagnosis. It is closest in general appearance to *Actinocoelia maeandrina* but differs in the larger size of the radial trabeculae relative to the radial canals, in the presence of the characteristic conical protuberances on the surface, in the grouping of the apopores into clusters, and in the presence of monaxons in at least some of the radial trabeculae. It shows some similarity also to *Defordia defuncta*, but that species lacks the conical protuberances.

MATERIAL: Eleven chertified specimens have been referred to this species.

OCCURRENCE: *Horizon:* Upper Leonardian. *Localities:* U.S.N.M. 702, 702b, 703b (Glass Mountains). *Biotopes:* Shelf and patch-reef facies. *Lithotopes:* Light limestones.

TYPES: Holotype, U.S.N.M. No. 127613 (from U.S.N.M. 703b); paratypes, U.S.N.M. Nos. 127614, 127615.

CHIASTOCLONELLID, GENUS AND SPECIES UNDETERMINED

Plate 10, figures 9, 10; plate 11, figure 1

DESCRIPTION: These are small sponges of irregular, spheroidal, fungiform, or subramose shapes. Their maximum dimensions are under 50 mm. Many possess a concentrically wrinkled, imperforate, basal surface which is overhung by the upper part of the sponge. The apopores are 0.2–0.5 mm. in diameter and are grouped in several clusters of from 12 to 45 pores, each cluster occupying a shallow, circular depression 2–6 mm. in diameter. Pores of similar size, which may or may not be prosopores, are scattered irregularly over the remainder of the smooth surface, 0.5–2.5 mm. apart. The fine skeletal pores are 0.07–0.17 mm. in diameter. About 15 short surface canals radiate from each of the apopore clusters, the remainder of the surface being free of grooves. The large pores lead into radial canals of the same diameter. The interior skeletal net has a generally radial arrangement, but the spicules are not aligned in regular series as in the anthaspidellids. The spicules include very typical X-shaped chiastoclones, frequently oriented with their axes parallel to the surface, as well as dendroclones and possibly tetraclones. The spicules are about 0.17–0.33 mm. in length and 0.03–0.07 mm. in shaft diameter.

DISCUSSION: This species probably represents a new genus, but it is too poorly preserved to be characterized adequately. There seems to be little doubt that it is a chiastoclonellid, for it possesses typical chiastoclones, as well as the radial architecture, the concentrically wrinkled imperforate base, and the grouping of the apopores in clusters that are characteristic of the family. The anthaspidellids have a very similar anatomy, differing in that the spicules are dendroclones arranged in very regular ladder-like series. The present species occurs together with the anthaspidellid *Multistella porosa*, new species, which it superficially resembles. Aside from the difference in the form and arrangement of the spicules, the present form differs further from *Multistella porosa* in that the apopore clusters are not stellate. It is possible to consider these sponges as individual variants of *M. porosa*, but to do so would involve the assumption that the separation of the Anthaspidellidae from the Chiastoclonellidae is invalid. As most species included in these two families seem consistently to retain the familial differences, it does not seem advisable at the present time to combine the two groups.

MATERIAL: Ten silicified specimens, prepared with acid, were available.

OCCURRENCE: A.M.N.H. 512, Getaway limestone member of Cherry Canyon formation (Guadalupian of Guadalupe Mountains); mixed basin and patch-reef facies.

ILLUSTRATED SPECIMENS: A.M.N.H. Nos. 28092, 28092:1, 28092:2.

FAMILY **JEREIDAE** DE LAUBENFELS, 1955

Jereidae DE LAUBENFELS, 1955, p. E57.

DIAGNOSIS: Skeleton composed of tetraclones and chiastoclones in irregular orientation; axial region of sponge occupied by large, parallel apochetes which open chiefly on the summit; prosochetes perpendicular to sides; specialized dermalia may be present.

DISCUSSION: The genera previously assigned to this family have been separated chiefly on the basis of body form and, in some cases, specializations of the spicules. The new genus *Jereina* here assigned to the family differs from the others in having apopore openings on the sides as well as the summit of the sponge. Except for this feature, its anatomical organization agrees with that of the other members of the family. The probable presence of chiastoclones along with regular tetraclones in the two species of *Jereina* may be a family character, for *Jerea* itself possesses such spicules (see De Laubenfels, 1955, p. E57, fig. 40,2). De Laubenfels (1955, p. E58) assigned *Anthracosycon* and *Laubenfelsia* tentatively to this family. The spicular net of these forms is, however, highly specialized and very different from that seen in typical jereids, so these two genera have been placed by the present writer in the family Anthracosyconidae. Consequently, the new Permian genus *Jereina* is the oldest known member of the family, all the other representatives being known only from Cretaceous rocks. *Jereina* may have been derived from sponges of the chiastoclonellid stock, for (in addition to the presence of chiastoclones and an irregular skeletal net) the grouping of apopores in clusters seen in *J. ramosa*, as well as the strong development of surface grooves, is a feature seen in many chiastoclonellids. The Permian *Jereina* may possibly be a homeomorph unrelated to the Cretaceous jereids, but the presence of chiastoclones in *Jerea* itself suggests a genetic relationship.

INCLUDED GENERA: The reader is referred to De Laubenfels (1955, p. E57) for a list of the genera included in this family. *Jereina*, new genus, should be added, and *Anthracosycon* and *Laubenfelsia* should be removed.

OCCURRENCE: Permian (Texas); Cretaceous (Europe).

JEREINA FINKS, NEW GENUS

DIAGNOSIS: Cylindrical and branching sponges; interior occupied, except for a thin outer rind, by parallel, closely spaced, vertical apochetes which terminate, singly or in groups, in large oscules or oscular depressions on both the summit and the sides of the sponge; prosochetes radial; prosopores closely and uniformly spaced over the surface and connected by deep, meandriform, and anastomosing grooves which divide the surface into flat-topped projections; skeletal net dense; junctions of spicules inflated and spherical; no dermal specialization.

DISCUSSION: The two species assigned here are separated chiefly on the basis of: (1) size and distribution of apochetes and apopores, and (2) over-all body size and shape. The genotype, *Jereina cylindrica*, new species, with its numerous and large vertical apochetes, is very similar to the Cretaceous species of *Jerea*. *Jereina ramosa*, new species, is less typical of the family, with its narrower apochetes and localized clusters of oscules. The swollen junctions between the spicules seen in both species of this genus may be a generic character. It is found in other tetracladine lithistids, for example, in *Callopegma* (see De Laubenfels, 1955, p. E55, fig. 37, 4b).

GENOTYPE: *Jereina cylindrica*, new species (Leonardian; Texas).

INCLUDED SPECIES: *Jereina cylindrica*, new species; *J. ramosa*, new species.

OCCURRENCE: Leonardian; Texas.

Jereina cylindrica Finks, new species

Plate 16, figures 1–3; plate 18, figures 3–8; plate 19, figures 1, 2

DIAGNOSIS: Large, cylindrical, and unbranched, with contracted base and flat, centrally depressed top; apochetes much larger than prosochetes and generally opening singly.

DESCRIPTION: The holotype is 140 mm. long and 50 mm. in maximum diameter, tapering to half of this width at the base and slightly contracted at the upper end. The other specimens are incomplete in length, but their diameters range from 30 mm. to 65 mm. The sides bear prosopores 0.4–1.5 mm. in diameter and 1.2–2.4 mm. apart, which lead into short, radial prosochetes of the same diameter. They are connected on the surface by anastomosing grooves of the same diameter spaced some 0.7–2.4 mm. apart. The fine skeletal pores are 0.05–0.25 mm. in diameter. Except for the outermost few millimeters, the interior of the sponge contains large longitudinal apochetes 1.2–4.2 mm. in diameter and separated by spaces approximately as wide. They open as oscules of similar diameter both at the upper end of the sponge and, to a lesser extent, along the sides. On the holotype several of the oscules at the upper end are at the bottom of a shallow cloacal depression 10 mm. wide and about 13 mm. deep. The remainder of the interior is occupied by a dense skeletal net of randomly arranged spicules, which appear to be normal tetraclones and possibly chiastoclones. Their junctions are noticeably inflated into spherical nodes about 0.13 mm. in diameter. Individual spicules could not be isolated.

BIOLOGICAL OBSERVATIONS: Two of the apochetes open at the basal end of the holotype specimen, the only individual on which the base is preserved. It may be that this end is broken, but the possibility exists that this sponge lay on its side on the sea floor and discharged water from each end. This possibility is also suggested by the fact that the oscules on the sides of the sponge seem to be confined to one side only, which may have faced upward. Such a repent position has been reported for several species of Recent sponges having a ramose growth form (see De Laubenfels, 1954, pp. 14, 81, and 85).

DISCUSSION: This species is differentiated from *J. ramosa*, new species, by its larger size, by the much larger size of the apochetes relative to the prosochetes, by the fact that the apochetes open singly rather than in clusters, and by its apparent lack of branching. This species may be confused with cylindrical individuals of *Actinocoelia maeandrina*, new species, but can be distinguished by the smoother surface and the parallel orientation of the large interior canals.

MATERIAL: Three specimens are available from P.U. 20g, three from P.U. 20f, one is from U.S.G.S. 14461, and one doubtful specimen each comes from U.S.N.M. 703b and P.U. 77. All are silicified.

OCCURRENCE: *Horizon:* Leonardian. *Localities:* P.U. 20f, 20g, 77; U.S.G.S. 14461 (Sierra Diablo); U.S.N.M. 703b (Glass Mountains). *Biotopes:* Shelf facies; patch-reef facies. *Lithotope:* Light bioclastic limestone.

TYPES: Holotype, P.U. No. 78875 (from P.U. 20g); paratypes, P.U. No. 78876, U.S.N.M. No. 127616.

Jereina ramosa Finks, new species

Plate 19, figures 3–7; text figures 39, 40

DIAGNOSIS: Ramose; slender cylindrical branches, with flat, slightly expanded tips, given off nearly at right angles; apochetes small and only slightly larger than the prosochetes; apochetes open in clusters, each at the bottom of a shallow depression; grooves and prosopores smaller and more closely spaced than in *cylindrica*.

DESCRIPTION: The typical specimens are branching cylinders 10–20 mm. wide, with branches as much as 75 mm. or more in length. The surface bears closely spaced, anastomosing grooves which separate rather rough projections. The canals are 0.4–0.6 mm. in diameter and are separated by spaces 0.3–1.5 mm. wide. The large prosopores are located in the floors of these canals and are 0.3–0.6 mm. in diameter and 0.9–1.2 mm. apart. These lead into radial prosochetes of the same diameter. The skeletal pores are 0.05–0.20 mm. in diameter. The apopores are 0.7–1.0 mm. in diameter and are grouped in clusters of a half dozen or so, which occupy shallow depressions 3–4 mm. in diameter located both at the tips of the branches and on their sides. Large surface canals 0.6–0.7 mm. in width radiate from these clusters. The apochetes are of the same diameters as the apopores and run longitudinally in the axial region of the interior of the sponge. They tend to be wider nearest the axis of the sponge. The remainder of the interior is occupied by a dense net of tetraclones and possibly chiastoclones 0.15–0.18 mm. long and 0.05 mm. in shaft diameter. The junctions of the spicules tend to be somewhat swollen into spherical nodes 0.1 mm. in diameter.

DISCUSSION: The foregoing description is based on the specimens from the type locality, U.S.N.M. 707e, and from an equivalent horizon, Y.P.M. 46. The fragment illustrated in plate 19, figures 3 and 4, from the lower horizon, U.S.G.S. 5777, is somewhat closer to *J. cylindrica* in its over-all size and in the spacing of the surface canals; the interior apochetes, however, are smaller than in *cylindrica*, so it has been assigned to the present species. The chief features by which the present species is separated from *cylindrica* are the smaller size of the longitudinal apochetes and the distribution of their external openings in clusters.

MATERIAL: Five silicified specimens were available, three from the type locality.

OCCURRENCE: *Horizon:* Leonardian. *Localities:* U.S.G.S. 5777; U.S.N.M. 707e; Y.P.M. 46. *Biotopes:* Basin facies; mixed basin and patch-reef facies. *Lithotope:* Dark limestones.

TYPES: Holotype, U.S.N.M. No. 127617 (from U.S.N.M. 707e); paratypes, U.S.N.M. Nos. 127618, 127619, Y.P.M. No. 19589.

ANTHRACOSYCONIDAE FINKS, NEW FAMILY

DIAGNOSIS: Skeleton composed principally of tetraclones and dendroclones, oriented vertically and organized into horizontal, or concentric, layers. Rhizoclones also present in small numbers.

DISCUSSION: The genera included in this family are separated on the basis of: (1) body form, (2) orientation of the spicule layers with respect to the sides of the sponge, and (3) distribution of pores and canals. The genus *Anthracosycon* Girty has been employed here to receive those species with a broad excurrent surface bearing numerous oscules, and in which the spicule layers are parallel to this surface, with their edges exposed on the sides of the sponge. The new genus *Collatipora* has been established for rounded sponges in which the spicule layers are parallel to the whole surface with their edges nowhere exposed, and in which the ostia are closely spaced in groups on limited areas of the sponge surface. As compared with *Anthracosycon*, the number of oscules is limited in this genus, and the surface canals are more numerous and widespread. *Dactylites*, new genus, likewise has the spicule layers parallel to the whole surface, but the oscules are at the ends of digitate branches, the ostia are evenly distributed over the whole surface, and surface canals are not well developed. *?Collatipora pyriformis* is somewhat intermediate between the last two genera in that the ostia are distributed over a large part of the sponge surface, and the surface canals are not numerous. In the whole family the abundance of the surface canals seems to be in inverse ratio to the degree to which the ostia are widespread; the more limited the surface area occupied by the ostia, the more abundant and widespread are the surface canals. The number of oscules is correlated with the degree to which a differentiated excurrent surface is developed; in *Anthracosycon*, in which such a surface is present, the oscules are numerous, but in the other genera there are relatively few. Just how much these differences in anatomy reflect environmental effects on individuals (ecophenotypes), rather than true genetic differences, is difficult to determine. The range of variability in many of the species is poorly known, and there are just enough variant individuals in some of them to suggest that the limits of species and genera should be more broadly interpreted than has been done in this paper. Given the presently available material, however, the classification established here seems best to reflect the consistencies in character correlation that can be observed.

The functional interpretation of the various pores and canals is another difficult problem. There can be little doubt that the largest openings, here called "oscules," as well as the large vertical canals that lead into them, served an excurrent function. Within the sponge the chief canals are those that run parallel to the spicule layers, probably originating as surface grooves that were subsequently covered over by the next-formed spicule layer, as well as a second set of canals perpendicular to the layers. Both sets are, at least in places, connected with each other, and the canals parallel to the layers are further connected with one another by large pores in the partitions between them. Both sets of canals seem to be connected with the large surface pores here called "ostia." Because of the abundance of these ostia, it is assumed that they served an incurrent rather than an excurrent function. With this assumption there seems to be no ground for identifying one set of interior canals as entirely excurrent in function and the other as entirely incurrent. It may be that some of both sets served one function and others the other function.

The layered structure of the skeleton in this family is unique among the tetracladine lithistids. In no other forms are the rhabdomes of the spicules uniformly oriented in a vertical or radial direction, and this structural arrangement is the basis for the establishment of this family. It may be regarded as a complementary counterpart to the structure of the family Anthaspidellidae, in which the rhabdomes are uniformly horizontal. As in that family, some of the spicules here have equally developed cladomes at both ends of the spicule and may be called dendroclones. Most of the spicules in this family, however, are true tetraclones, with a distinctly larger, three-branched cladome at one end. In those species in which the spicules in each layer are grouped into bundles, the rhabdomes frequently develop short lateral processes which connect with the adjacent spicules. Such spicules resemble the rhizoclones of the Rhizomorina. Furthermore many of the pores and canals are partly outlined by apparently monocrepid spicules bearing processes on one side. As these rhizoclone-like spicules are subordinate in number to true tetraclones, this family is placed in the suborder Tetracladina. However, the presence of these spicules suggests a fairly close relationship between the Tetracladina and the Rhizomorina, particularly as tetraclones are present in subordinate numbers in many rhizomorines.

INCLUDED GENERA: *Anthracosycon* Girty, 1909 ("*Laubenfelsia*" R. H. King, 1943); *Collatipora*, new genus; *Dactylites*, new genus.

OCCURRENCE: Permian; Texas.

GENUS **ANTHRACOSYCON** GIRTY, 1909

Anthracosycon GIRTY, 1909, p. 72. R. H. KING, 1943, p. 20.

Laubenfelsia R. H. KING, 1943, p. 9.

DIAGNOSIS: Conical to fungiform, with broad, flat, excurrent, upper-surface; spicule layers parallel to top surface, their edges exposed on the sides; numerous large, often elliptical oscules on top surface; ostia uniformly distributed over whole surface, especially sides; surface canals most abundant at edge of top surface.

DISCUSSION: The species of this genus are separated on the basis of: (1) over-all size and (2) whether or not the spicules are grouped in bundles. The species *auriforme*, assigned tentatively to the genus, differs from the other two species in its body form and in the size, shape, and number of its oscules. The broad, flat, excurrent surface, the numerous oscules, and the exposure of the edges of the spicule layers on the sides of the sponge are the principal generic characters. *?Anthracosycon auriforme* differs from the other species in its thinness and in the great expanse of the excurrent surface, as well as in the smaller size and circular shape of the oscules. Its shape can be regarded, however, as a highly asymmetrical version of the conical form of the other two species. *Anthracosycon regulare*, which is the genotype of *Laubenfelsia*, is so similar to the genotype of *Anthracosycon* that *Laubenfelsia* must be regarded as a junior synonym. Both these forms share a more symmetrically conical shape, and both possess large elliptical oscules. The holotype specimens of each are somewhat skewed to one side and could give rise by further development of asymmetry to the shape of *auriforme*. *Anthracosycon* sp. reported by Etheridge (1917, p. 251, pl. 39, fig. 1) from the Carboniferous of Australia cannot be identified from the description and illustration given.

GENOTYPE: *Anthracosycon ficus* Girty, 1909 (Leonardian; Texas).

INCLUDED SPECIES: *Anthracosycon ficus* Girty, 1909; *A. regulare* (R. H. King, 1943); *?A. auriforme*, new species.

OCCURRENCE: Leonardian, Guadalupian; Texas.

Anthracosycon ficus Girty, 1909

Plate 20, figures 1–5; text figures 41–44

Anthracosycon ficus GIRTY, 1909, p. 72, pl. 24, figs. 1, 1a, 2. R. H. KING, 1943, p. 20.

Not *Anthracosycon ficus* var. *capitanense* Girty, 1909, p. 72, pl. 7, fig. 10.

DIAGNOSIS: Small; spicules of each layer grouped in bundles.

DESCRIPTION: The following description is based on the holotype, but the paratype, which is a smaller and more irregularly shaped individual, agrees with its essential characters. The holotype is a broad, low, asymmetrical cone, with the base at one side. It stands 19 mm. high, and the top surface is subcircular in outline and 23 mm. in diameter. The upper surface is flat or slightly concave in the center and slopes down gently about the periphery where it meets the sides. Ten or more oscules are located in the central part of the top surface. Most are elliptical and range in size from 0.7 by 1.7 mm. to 1.7 by 2.7 mm. There are also two circular ones 0.9 mm. and 1.7 mm. in diameter, respectively. Irregular surface canals 0.2–0.5 mm. wide are concentrated on the peripheral part of the top surface where they tend to have a radial orientation. They do not connect with the oscules on the surface. On both top and sides there are numerous circular ostia 0.15–0.50 mm. (mostly 0.3 mm.) in diameter. Those on the top are somewhat irregularly spaced, but those on the sides are quite uniformly and closely spaced, 0.5–0.8 mm. apart. Two or three adjacent ones on the sides may be connected by a short surface canal which proceeds inward and upward into the sponge between the layers of spicules and probably corresponds to the surface canals of the top of the sponge. Some of these horizontal canals are higher than wide and encompass the space occupied by two spicule layers. Many of the ostia, however, lead into canals which run inward and downward, perpendicular to the spicule layers. The ostia and oscules of the upper surface connect with similar vertical canals. The spicule layers of the interior are parallel to the upper surface of the sponge. Like it, they are down-turned peripherally, and their edges are exposed on the sides of the sponge. The upper surface represents the top of the last-formed spicule layer and is microhispid from the projecting arborescent processes of the spicule cladomes. The sides of the sponge bear no special dermal layer but are formed by the imbricating edges of the successive interior spicule layers. The skeletal pores between the spicules are 0.03–0.10 mm. in diameter.

The spicules are mostly tetraclones with smooth rhabdomes and strongly arborescent clads; there is a three-branched cladome at one end and a smaller arborescent expansion at the opposite end of the rhabdome. Some of the spicules have nearly equal expansions at each end and resemble dendroclones. Where the tetraclones are closely grouped into bundles, short lateral processes may develop on the rhabdomes. The length of these spicules increases from the basal to the upper parts of the sponge, averaging 0.10–0.13 mm. near the base and as much as 0.4–0.5 mm. in the uppermost layers. The rhabdome thicknesses are fairly constant at about 0.03–0.05 mm., and the large cladome is about 0.3 mm. across. The larger circular canal openings may be bounded by strongly lengthened and curved clads of the regular spicules, or they may in some cases be outlined by curved rhizoclone-like spicules, with the concave side smooth and the convex side bearing numerous short processes. The spacing of the spicule layers is equal to the length of the spicules themselves and therefore increases from base to top of the sponge. In the first 4 mm. above the base, the horizontal canals are not well developed, and the spicules are not grouped in bundles but are spaced more or less uniformly about 0.1 mm. apart. Above the basal region the rhabdomes tend to be grouped in bundles which separate the horizontal canals. As most of the canals are radially disposed, the bundles are elongate in this direction. At first they consist of a single series of spicules lined up along the course of the canal. In the upper two-thirds of the sponge, however, these partitions are from two to four spicules thick between the adjacent canals. The rhabdomes are in more or less continuous contact, both across the partition and down its length. These partitions are 0.08–0.18 mm. thick and separate canals 0.2–0.5 mm. wide. These partitions are pierced by pores which connect adjacent canals. These pores range in size from 0.03 mm. to 0.5 mm.

BIOLOGICAL OBSERVATIONS: The holotype apparently began its development attached to a shell fragment of some sort which is preserved on the specimen as a horizontal slit-like mold a short distance above the base. The initial layers of spicules are on the under side of this shell mold with respect to the present orientation of the sponge. The sponge continued its growth around the edge of the shell, so that the spicule layers gradually curved through 180 degrees and ultimately overlapped the upper surface of the shell. The sponge may therefore have initially grown downward, or the shell may have been turned over shortly after the sponge settled on its upper surface.

DISCUSSION: The anatomical description of this specimen has been considerably amplified from that given by Girty, because subsequent preparation with acid removed patches of adherent matrix that covered part of the upper surface as well as the base of the specimen. This revealed several of the large oscules, not seen by Girty, as well as the shell mold near the base. It also made possible a closer examination of the skeletal net and the separation of individual spicules from it. R. H. King's subsequent description of specimens that he referred to this genus agree with the present writer's observations of the holotype. Neither Girty nor King observed the layered structure of the skeleton, which is so characteristic of the whole family. King is quite right in pointing out that Girty's description of the slight central depression on the upper surface of the holotype as a "cloaca" is misleading. Although the area containing the oscules is functionally equivalent to the lining of a cloaca, the degree of depression of this surface on the holotype should scarcely be dignified with such a term. King notes that on other specimens which he referred to this species, the upper surface is convex, a condition also present in Girty's paratype specimen. The monaxons which both Girty and King observed adhering to some of the specimens are, in the writer's opinion, foreign to the sponge. No such monaxons could be seen incorporated in a regular way into the skeletal net of the sponge.

This species, the range of variability of which is poorly known, is very close to *A. regulare* (R. H. King) which is the genotype of *Laubenfelsia* King. The discovery of elliptical oscules on the holotype of *A. ficus*, as well as the layered arrangement of its spicular net, leaves very few differences between the two species. The most consistent difference is the absence of bundling of the spicules in *regulare*. This seems to be significant, for the degree of bundling increases with growth in *A. ficus*, and all the known specimens of *A. regulare* are larger than the holotype of *ficus* yet show no significant grouping of the spicules.

The specimens described by Girty as *A. ficus* var. *capitanense* are not related to *Anthracosycon* but are calcareous pharetronid sponges, probably related to *Stellispongia*.

MATERIAL: The present redescription of this species is based on the original holotype and paratype specimens of Girty.

OCCURRENCE: *Horizon:* Leonardian (Bone Spring limestone). *Locality:* U.S.G.S. 2920 green (Guadalupe Mountains). *Biotope:* Basin facies. *Lithotope:* Dark, bituminous, spiculiferous limestone.

TYPES: Holotype, U.S.N.M. No. 118127; paratype, U.S.N.M. No. 118154.

Anthracosycon regulare (R. H. King, 1943)

Plate 20, figures 6–11; plate 21, figures 1, 2; text figures 45–50

Laubenfelsia regularis R. H. KING, 1943, p. 10, pl. 2, figs. 3–5.

DIAGNOSIS: Large; spicules not grouped in bundles.

DESCRIPTION: The shape of this species is variable but is generally conical, with a more or less elliptical cross section. The sides of the holotype are somewhat flaring and meet the slightly depressed upper surface in a sharp but rounded rim. Other specimens are less regular: one is constricted towards the top, and another bears an incipiently digitate protuberance at one end of the top surface. The heights range from 40 mm. to 80 mm., and maximum diameters from 23 mm. to 82 mm. Most of the upper surface is covered with circular to elliptical oscules 1.8–3.6 mm. in diameter and spaced the same distance, or less, apart. The vertical apochetes, of which they are the openings, may run for nearly the whole height of the sponge. Between the oscules on the upper surface there are meandriform, anastomosing, surface canals 0.2–0.9 mm. wide as well as circular ostia 0.2–0.6 mm. in diameter, which are located both in the floors of the canals and on the surface between them. Vertical and horizontal canals of the same widths occur 0.9–1.8 mm. apart within the sponge and were presumably formed in connection with the ostia or as surface canals at earlier stages of growth. The horizontal canals open on the sides of the sponge. The openings are frequently elongate vertically, as the canals are often two or three times higher than wide and extend through two to five successive spicule layers of the skeletal net. The fine skeletal pores are 0.05–0.20 mm. in diameter. The spicule layers are 0.2–0.4 mm. apart and are parallel to the upper surface, so that their edges are exposed on the sides of the sponge. Near the base of some specimens the layers are more strongly downturned peripherally, so that there is a dermal layer on the sides similar to that of the top surface. Young specimens therefore must have a strongly convex upper surface. The spicules are mostly tetraclones with smooth shafts, though some resemble dendroclones. The spicules are 0.2–0.4 mm. long, 0.03–0.08 mm. in shaft diameter, and 0.13–0.23 mm. in cladome width. Except where wider canals intervene, the rhabdomes are spaced 0.08–0.26 mm. apart in each layer, and there is almost no grouping of the spicules in bundles. Around the canals and ostia some spicules may be oriented with the rhabdome horizontal.

DISCUSSION: This species, which is the genotype and sole species of *Laubenfelsia* King, 1943, is so close to *Anthracosycon ficus* that there can be no doubt of the synonymy of the two genera. Aside from the larger size of the specimens of the present species, the chief difference is in the lack of bundling of the spicules within the layers. The more numerous oscules in the present species may also be a specific difference.

MATERIAL: The silicified holotype was studied along with five other topotypes, three of which were silicified, one partly calcified, and one wholly calcified. In addition three specimens from other localities have been referred to this species.

OCCURRENCE: *Horizons:* Leonardian, Guadalupian. *Localities:* A.M.N.H. 500, 547; U.S.N.M. 707ha, 707q (Glass Mountains, Guadalupe Mountains). *Biotopes:* Basin facies, mixed basin and patch-reef facies; patch-reef facies. *Lithotopes:* Dark limestones; light limestones.

TYPES: Holotype, K.U. No. 74147: paratype, K.U. No. 74148, A.M.N.H. No. 28093, U.S.N.M. Nos. 127620a, 127620b.

?**Anthracosycon auriforme** Finks, new species

Plate 21, figures 3–5

DIAGNOSIS: Auriform, concave surface corresponding to top, and convex surface to side; oscules small and circular; surface canals on narrow edge; spicules not grouped in bundles.

DESCRIPTION: The single specimen is a small, ear-shaped sponge 48 mm. wide, 30 mm. high, and 7 mm. thick. The concave, probably excurrent, side is covered with numerous circular oscules 0.8–1.1 mm. (mostly 0.9 mm.) in diameter, rather widely spaced 1.5–4.2 mm. apart. Between them are smaller ostia, 0.2–0.6 mm. (mostly 0.4 mm.) in diameter and 0.4–1.2 mm. apart. The surface between the pores is smooth and bears skeletal pores 0.025–0.150 mm. in diameter. The convex, probably incurrent, side bears many closely spaced small ostia, 0.3–0.5 mm. in diameter and 0.9 mm. apart. The smooth interspaces between them bear skeletal pores like those of the opposite side of the sponge, but large areas of this side are either decorticated or never developed a surface layer, and the edges of the interior spicule layers are exposed. Surface canals, 0.3–0.6 mm. in width, are developed on the narrow upper edge and run perpendicular to the two broad surfaces of the sponge. They frequently connect several ostia in a vertical row near the upper edge of the convex side and branch as they approach the concave side. These surface grooves are probably equivalent to the prosochetes of the interior. Some of the canals bordering the concave side converge on some of the large ostia and may have functioned as apochetes. The canals of the interior are difficult to follow. Some of the ostia of the convex side lead into canals which run perpendicular to the spicule layers of the interior, but others lead into canals, often much higher than wide, which run parallel to the spicule layers. The large pores of the concave side connect with canals perpendicular to the spicule layers, and horizontal canals, some just under the surface, empty into them. The spicule layers of the interior are parallel to the rounded upper edge and, at least in part, to the concave surface. The continuous smooth surface on the concave side probably represents in general the outermost of these spicule layers. That covering parts of the convex side is probably formed by a single layer of spicules parallel to the surface. The individual spicules are smooth-shafted tetraclones, 0.2–0.3 mm. long and 0.05–0.07 mm. in shaft thickness, oriented with the cladome uppermost. They are not grouped in bundles but are uniformly spaced in each layer 0.15–0.20 mm. apart and alternate in position in successive layers.

BIOLOGICAL OBSERVATIONS: The sponge appears to have begun its growth from approximately the center of the basal edge. It appears, however, to have been attached to one or more objects in the substratum over much of the lower portion of the convex side, so that the concave side must have faced upward as well as laterally. A cylindrical region 5 mm. in diameter completely penetrates the sponge somewhat above its initial point of origin and appears to be the poorly preserved remains of a crinoid stem or similar object overgrown by the sponge.

DISCUSSION: This sponge has been tentatively assigned to *Anthracosycon* on the assumption that the concave surface corresponds to the top of the more typical conical or ficiform members of the genus. The convex side then becomes the homologue of the sides of typical forms and shows one of the characteristic features of the genus, namely, that the spicule layers meet this side more or less perpendicularly. The large pores of the concave side correspond to the larger, less numerous, and more elliptical oscules found in the other two species of the genus.

MATERIAL: One silicified specimen, prepared with acid, was available.

OCCURRENCE: *Horizon:* Leonardian (Bone Spring limestone). *Locality:* U.S.G.S. 6938 (Sierra Diablo). *Biotope:* Basin facies. *Lithotope:* Dark limestone.

TYPE: U.S.N.M. No. 127621.

COLLATIPORA FINKS, NEW GENUS

DIAGNOSIS: Spheroidal; spicule layers concentric and parallel to whole surface; one or several circular oscules; ostia mostly confined to one or more restricted fields; surface canals anastomose over most of surface except for ostial fields.

DISCUSSION: The species assigned to this genus are differentiated with respect to: (1) body form, (2) number and size of ostial fields, (3) size of ostia, and (4) whether or not the spicules are grouped in bundles. The species *pyriformis*, tentatively assigned here, differs further in the paucity of its surface canals. The genus as a whole is distinguished from both *Anthracosycon* and *Dactylites* by the concentration of the ostia in limited areas and by the strong development of surface canals; it is further distinguished from *Anthracosycon* by the concentric rather than horizontal arrangement of the spicule layers. The ostial field in *?Collatipora pyriformis* covers a large area of the sponge surface and in some individuals seems to cover most of it. This, together with its more limited development of surface canals, brings it close to *Dactylites*.

GENOTYPE: *Collatipora discreta* Finks, new species (Leonardian, Guadalupian; Texas).

INCLUDED SPECIES: *Collatipora discreta* Finks, new species; *C. delicata* Finks, new species; *?C. pyriformis* Finks, new species.

OCCURRENCE: ?Wolfcampian, Leonardian, Guadalupian; Texas.

Collatipora discreta Finks, new species

Plate 21, figure 6; plate 22, figures 1–5;
plate 24, figure 9

DIAGNOSIS: Spheroidal or ellipsoidal; more than one ostial field; ostia large for genus, spicules grouped in bundles.

DESCRIPTION: The two specimens referred with certainty to this species are flattened ovoid individuals about 30 mm. in the longest dimension and about 16 mm. in the shortest dimension. Each has four elliptical ostial fields spaced over the presumed upper surface. These fields range in size from 3 by 6 mm. to 7 by 12 mm., and each contains from 13 to 40 closely spaced circular ostia, 0.4–1.0 mm. in diameter. There are in addition two or three larger oscules of somewhat stellate form, 1.2–2.0 mm. in diameter. The remainder of the surface is covered with branching surface canals, 0.3–0.6 mm. in width and 0.8–3.0 mm. apart, which converge on the ostial fields and on the oscules. The intervening parts of the surface are smooth and bear only fine skeletal pores 0.03–0.30 mm. in diameter. The skeletal net is organized into concentric layers parallel to the surface. The spicules are mostly tetraclones, 0.07–0.30 mm. long and 0.03–0.05 mm. in shaft diameter, and tend to be grouped in bundles of a few spicules each.

DISCUSSION: This species is distinguished from *C. delicata* by the larger size of the ostia, by the grouping of the spicules in bundles, and by the presence of more than one oscule and ostial field. It differs from *?C. pyriformis* in the restriction of the ostia to small discrete areas, by the abundance of surface canals, and by the more feebly developed grouping of the spicules in bundles. Two specimens that superficially resemble this species are illustrated (pl. 21, fig. 6; pl. 24, fig. 9). They differ in lacking oscules, and their spicular structure is unknown. They may not belong to this genus at all.

MATERIAL: Two silicified specimens prepared with acid have been referred to this species. The two doubtful forms referred to above come from U.S.N.M. 706 and U.S.N.M. 702, respectively.

OCCURRENCE: *Horizons:* Leonardian, Guadalupian (Bell Canyon). *Localities:* A.M.N.H. 389 (Guadalupe Mountains); Y.P.M. 37 (Glass Mountains). *Biotope:* Basin facies. *Lithotope:* Dark limestone.

TYPES: Holotype, A.M.N.H. No. 28094 (A.M.N.H. 389, Rader limestone); paratype, U.S.N.M. No. 127622.

Collatipora delicata Finks, new species

Plate 22, figures 6–12

DIAGNOSIS: Encrusting, hemispherical; one ostial field and one or a few oscules; ostia small for genus; spicules not grouped in bundles.

DESCRIPTION: All the specimens referred with certainty to this species are encrusting forms growing on calcareous sponges or Bryozoa. Their shape is somewhat determined by the substratum but tends to be hemispherical. The maximum diameter of the sponge is 15–20 mm., and its thickness 7–10 mm. A single ostial field, ranging in size and shape from a circular area 5.5 mm. in diameter to an elliptical patch 8 by 12 mm. across, is present on the top surface. The number of ostia in the field ranges from about 30 to as many as 75. They are small, 0.2–0.6 mm. in diameter, and are separated by spaces approximately equal to their own diameter. Isolated ostia of the same size may occur on other parts of the surface, including the floors of the surface grooves. From one to four circular oscules, 0.5–1.5 mm. (mostly 1.0 mm.) in diameter, are present on other parts of the upper surface. The remainder of the surface bears anastomosing surface grooves, 0.2–0.4 mm. wide and two or three times as deep, and spaced 0.5–1.5 mm. apart. The grooves tend to converge on the ostial field and on the oscules; some may sink below the surface and continue as horizontal canals on the interior. The surface between the pores and canals is smooth and bears fine skeletal pores, 0.025–0.150 mm. in diameter. The interior contains radial canals connecting with the ostia and oscules, as well as horizontal canals between the spicule layers, which probably correspond to the surface grooves. The spicule layers are concentric and parallel to the surface. They are composed chiefly of smooth-shafted tetraclones, 0.06–0.23 mm. long and 0.02–0.05 mm. in shaft thickness. The spicules are not grouped in bundles. Some larger spicules, up to 0.3 mm. long, extend horizontally across some of the surface grooves.

BIOLOGICAL OBSERVATIONS: The encrusting habit seems to be associated with this species. They have been found on various ramose bryozoan colonies and on the calcareous sponge *Guadalupia zitteliana* Girty. In some cases mutual overgrowth indicates that the host individual was alive while the sponge was growing on it. Some specimens have themselves been overgrown by encrusting Bryozoa, again, in at least one case, while both were alive.

DISCUSSION: The characteristic members of this species are confined to the Getaway limestone bioherm at A.M.N.H. 512 (U.S.N.M. 728). Somewhat similar forms with less clearly defined ostial fields have been found at U.S.N.M. 705a and 701, and at U.S.G.S. 7621 and 8548; these forms are probably related to the present species, but their conspecificity is doubtful. One from U.S.N.M. 705a is illustrated on plate 22, figure 8. The present species is distinguished from its closest relative, *C. discreta*, by the presence of a single ostial field, by the smaller size of the ostia, and by the lack of bundling of the spicules.

MATERIAL: Five silicified, acid-prepared specimens were available from A.M.N.H. 512, and two from U.S.N.M. 728. Both the holotype and the illustrated paratype are attached to individuals of *Guadalupia zitteliana* Girty.

OCCURRENCE: *Horizon:* Guadalupian (Getaway limestone member of Cherry Canyon formation). *Localities:* A.M.N.H. 512; U.S.N.M. 728 (Guadalupe Mountains). *Biotope:* Mixed basin and patch-reef facies. *Lithotope:* Dark bituminous limestone.

TYPES: Holotype, A.M.N.H. No. 28095 (A.M.N.H. 512); illustrated paratype, U.S.N.M. No. 127625; other paratypes, A.M.N.H. Nos. 28095:1–28095:4, U.S.N.M. No. 127626.

?**Collatipora pyriformis** Finks, new species

Plate 23, figures 1–13; text figures 51–55

DIAGNOSIS: Stipitate; oscules numerous and concentrated at summit; ostial field covering one whole side of sponge; ostia large; surface canals confined to vicinity of oscules; spicules strongly grouped in bundles.

DESCRIPTION: The only complete individual has a laterally compressed spheroidal shape with a pedunculate base. The whole sponge is 26 mm. high, the short cylindrical stalk is 6 mm. in diameter, and the body is 29 mm. in one horizontal dimension and 18 mm. in the other. A dozen or so circular oscules, 1.0–1.5 mm. in diameter, are irregularly spaced along the upper edge of the sponge. Each is surrounded by a low rim, which is more strongly developed on those farther down the sides of the sponge. One flat side of the body is completely covered with closely spaced circular ostia, 0.6–0.9 mm. in diameter and approximately 1.5 mm. apart. Near the top end the ostia are smaller, being 0.3–0.6 mm. in diameter. On other specimens all the ostia fall within this size range. A single oscule, like the oscules on the top of the sponge, is present near the base of this side at the summit of a low mound. Surface canals connecting some of the ostia are present in the vicinity of this oscule, and similar surface canals are present on the top of the sponge, branching away from the side bearing the ostia. None of the surface canals connects directly with the oscules; they are probably equivalent to the prosochetes of the interior. The sponge surface between the large pores and canals is smooth and bears only fine skeletal pores, 0.025–0.130 mm. in diameter. The other flat side of the body, as well as the stalk, bears no other openings than these skeletal pores. An additional point of attachment seems to be present in the middle of this flat side. The other fragmentary specimens appear to be parts of similarly organized sponges, though the shape may vary, and some may have been hemispheroidal without a stalk.

The smooth outer surface of the sponge is formed by the arborescent cladomes of the spicules of the outermost layer. The internal arrangement of the spicule layers is more or less concentric. The spicules themselves are mostly tetraclones, with a generally smooth rhabdome and finely arborescent ends. Some of the rhabdomes have short lateral processes which connect with the rhabdomes of adjacent spicules. The large cladome appears to be oriented uppermost. Short, horizontally oriented tetraclones may connect adjacent rhabdomes in the spicule bundles. The spicules are about 0.23 mm. long, and the rhabdome is about 0.03 mm. thick. In each layer the spicules are strongly grouped into bundles which separate subparallel horizontal canals of circular cross section between the layers. These canals are connected laterally by circular openings and are also connected between the layers by radial canals which lead in from the ostia. Most of the radial and horizontal canals have diameters in the same size range as the ostia, but there are smaller openings in both directions which range in diameter from that of the smallest ostia down to that of the skeletal pores. It seems likely that the radial canals are mostly prosochetes and the horizontal canals apochetes.

BIOLOGICAL OBSERVATIONS: The concentration of the presumably incurrent ostia on one face of the sponge in the holotype specimen suggests a possible orientation with respect to the direction of the ambient water currents. The excurrent oscules are concentrated on the top edge, as is to be expected.

Those oscules in more sheltered positions, lower down on the side opposite the ostia, have higher lips; this is a common adaptation in sponges to strengthen the force of the outgoing current in quieter water, and suggests that this side of the sponge was in the lee of the ambient currents. This side may also have been sheltered by objects on the substratum, for there is an attachment scar on this side of the sponge as well as at the base of the stalk. One of the fragmentary specimens at the same locality shows the same distribution of ostia and oscules. Two others, however, have ostia on all sides of the sponge, with the oscules on the top; one of these individuals is ovoid and the other flabellate and incipiently digitate. Still another individual is bun-shaped, and the ostia are concentrated in three poorly defined fields on the upper surface. Because these specimens are all from the same locality and show the same strong grouping of the spicules into bundles, it is likely that they are conspecific. The external form, therefore, is rather variable and must depend on the immediate environment.

DISCUSSION: This species is rather intermediate between the typical sponges assigned to *Collatipora*, which have sharply limited ostial fields, and *Dactylites* in which the ostia are uniformly distributed over the whole surface. As some individual variants assigned to this species closely approach both these end terms, the question arises whether these two genera should not be combined. Inasmuch as the presently available material suggesting continuity is fragmentary and poorly preserved, it seems best to recognize two genera and wait for better material before conclusions are drawn as to the range of variation. The present species is distinguished from the other two species of *Collatipora* by the paucity of surface canals and by the wide extent of the single ostial field. It is distinguished from *Dactylites* by the absence of ostia on parts of the sponge and by the lack of a digitate form. The strongly developed bundling of the spicules distinguishes it from all the other species in the family.

MATERIAL: One complete specimen and five fragmentary ones were available from U.S.N.M. 703c; one fragment was also present in the collections from the essentially equivalent A.M.N.H. 503. All are silicified and were prepared with acid.

OCCURRENCE: *Horizon:* Leonardian (Word limestone number 1). *Localities:* A.M.N.H. 503, U.S.N.M. 703c (Glass Mountains). *Biotope:* Mixed basin and patch-reef facies. *Lithotope:* Dark, bituminous, spiculiferous limestone.

TYPES: Holotype, U.S.N.M. No. 127629 (from U.S.N.M. 703c); paratypes, U.S.N.M. Nos. 127630a–127630d, A.M.N.H. No. 28096.

DACTYLITES FINKS, NEW GENUS

DIAGNOSIS: Digitate; spicule layers concentric and parallel to surface; circular oscules terminal; ostia uniformly distributed over whole surface; few surface canals.

DISCUSSION: The internal structure of this genus is not well understood. Two species are assigned here, one tentatively. They are differentiated with respect to: (1) body form and (2) size of ostia. Aside from the digitate form, which may not be a generic character, this genus is differentiated from the other members of the family by the unique combination of a smooth surface, uniformly distributed ostia, and few surface canals. Its spicule layers are probably concentric, as in *Collatipora*, rather than horizontal, but this could not be clearly seen.

GENOTYPE: *Dactylites micropora* Finks, new species (Leonardian; Texas).

INCLUDED SPECIES: *Dactylites micropora* Finks, new species; *?Dactylites subdigitatus* Finks, new species.

OCCURRENCE: Leonardian; Texas.

Dactylites micropora Finks, new species

Plate 19, figures 8–10; plate 24, figures 1–5;
text figures 56–59

DIAGNOSIS: Strongly digitate; ostia small for genus; spicules probably not grouped in bundles.

DESCRIPTION: This is a small sponge with long cylindrical branches, which may branch again, springing from a common, encrusting base. The holotype is 25 mm. high and has two main branches 6 mm. and 7 mm. in diameter, one of which bears two incipient branches. At the tip of each branch is a single circular oscule 1.2–1.5 mm. in diameter. The whole sponge is covered by a smooth dermal layer which bears numerous circular ostia, 0.3–0.5 mm. in diameter and 0.5–1.2 mm. apart. Short surface canals may connect some of these ostia, but canals are not numerous. The remaining part of the surface bears only skeletal pores 0.025–0.200 mm. in diameter. The spicules are tetraclones and dendroclones 0.1–0.3 mm. long and 0.02–0.05 mm. in rhabdome thickness. The internal arrangement of the spicule layers could not be clearly seen, but the layers appear to be parallel to the surface, and the spicules do not seem to be grouped into bundles.

BIOLOGICAL OBSERVATIONS: The base of the holotype bears several concave areas which are presumably molds of objects in the substratum. One of them is lined with short, curved strongyles about 0.4 mm. in chord length and 0.1 mm. thick. A small fragment of *Pileolites baccatus* is embedded in the side of the same specimen and was presumably overgrown by the sponge. The three specimens assigned to this species were associated in a block of limestone consisting almost entirely of small lithistid and hexactinellid sponges crowded together. The composition and environment of this block are discussed in the first part of the paper.

DISCUSSION: The same digitate form is shown by the three individuals available for study and is presumed to be a characteristic of the species.

MATERIAL: Three silicified specimens were revealed by acid treatment of a single block of limestone; the paratypes are still embedded in the block.

OCCURRENCE: *Horizon:* Leonardian (base of Bone Spring limestone). *Locality:* P.U. 80c (Sierra Diablo). *Biotope:* Basin facies. *Lithotope:* Dark, bituminous, spiculiferous limestone.

TYPES: Holotype, P.U. No. 78881; the paratypes are on the block bearing the number P.U. No. 78862.

?Dactylites subdigitatus Finks, new species

Plate 24, figures 6–8; text figures 60–64

DIAGNOSIS: Conical, becoming digitate; ostia large for genus; spicules not grouped in bundles.

DESCRIPTION: The sponge as a whole is conical, 45 mm. high, the base 11 mm. in diameter, and the top 26 mm. by 33 mm. in diameter. Around the periphery of the upper surface there are five circular oscules, 1.8–2.4 mm. in diameter, one of them at the summit of a short digitate projection. The smooth dermal layer, where preserved, is pierced by uniformly spaced circular ostia, 0.3–0.7 (mostly 0.6) mm. in diameter and 0.6–1.5 mm. apart. Discontinuous surface canals connect many of the ostia, particularly on the upper surface. The ostia connect with anastomosing interior canals of the same diameter as the ostia. The spicule layers are parallel to the upper surface but are downbent peripherally so as to be more or less tangential to the sides. The spicules are mainly tetraclones but also include dendroclones with three clads at each end. The smooth rhabdomes are 0.15–0.30 mm. long and 0.036–0.061 mm. thick; the arborescent cladomes are 0.15–0.20 mm. wide. The canals and ostia are frequently outlined by curved monocrepid desmas resembling rhizoclones. They are smooth on the concave side and bear arborescences on the convex side. These spicules are 0.3–0.4 mm. in chord length and 0.05–0.07 mm. thick. The cladomes of the tetraclones may also outline the canals and ostia in a similar way. The spicules are not notably grouped in bundles.

BIOLOGICAL OBSERVATIONS: The center of the top surface bears a conical depression which is partly occupied by an encrusting bryozoan. The presence of the bryozoan may have restricted the development of the oscules to the periphery. A leptodid brachiopod shell encrusts one side of the base of this sponge; it is oriented with the anterior end uppermost. Both of these organisms probably lived on the sponge during its lifetime.

DISCUSSION: The uniform distribution of the ostia over the whole smooth dermal surface and the incipiently digitate form of the sponge are the chief reasons for assigning this form to *Dactylites*. The ostia are larger than in the genotype. The general body form resembles that of *Anthracosycon regulare*, but that species does not show a smooth dermal layer on the sides of the sponge.

MATERIAL: One silicified specimen, prepared with acid, was available.

OCCURRENCE: *Horizon:* Leonardian (Bone

Spring). *Locality:* P.U. 3e (Sierra Diablo). *Biotope:* Basin facies. *Lithotope:* Dark limestone.

TYPE: P.U. No. 78880.

TETRACLADINE SPONGE, GENUS AND SPECIES UNDETERMINED

Plate 14, figures 1, 2

DESCRIPTION: This is a small fragment 13 mm. by 17 mm. in diameter and 8 mm. thick. The two flat sides apparently represent an incurrent and an excurrent surface, respectively, so that the whole sponge was either vasiform or foliate. On the somewhat convex, presumably incurrent side there are circular pores 0.8–1.0 mm. in diameter and 1.5 mm. apart; on the concave, excurrent side there are similar pores 0.7 mm. in diameter, spaced 1.2 mm. apart. Between the larger pores on both surfaces there are smaller openings 0.2–0.4 mm. in diameter, and the skeletal pores between the spicules are about 0.1 mm. in diameter. The larger openings lead into anastomosing canals of similar diameter on the interior. The spicular net consists of irregularly arranged tetraclones approximately 0.5 mm. long. Some may have the form of chiastoclones, and many have short lateral processes along the main shaft of the spicule. A few slightly curved oxeas, 0.7 mm. long, were found loose in the skeletal net; they may be foreign.

DISCUSSION: This sponge is too fragmentary to be identified. Its spicules are very similar to those of *Defordia*, but its apparent possession of differentiated incurrent and excurrent surfaces would seem to separate it from the Chiastoclonellidae.

OCCURRENCE: A.M.N.H. No. 28091, from A.M.N.H. 547, Getaway limestone member of Cherry Canyon formation, Guadalupian, Guadalupe Mountains, mixed basin and patch-reef facies.

SUBORDER **RHIZOMORINA**
ZITTEL, 1878

DIAGNOSIS: Principal spicules rhizoclones.

DISCUSSION: The families assigned to this suborder have been separated on the basis of: (1) general body form and architecture, (2) size, shape, and arrangement of pores and canals, (3) dermal specialization, and (4) the general types of spicules present in addition to rhizoclones.

Many of the species included in this group possess smooth monaxons, tetraclones, and specialized dermal spicules, in addition to the characteristic rhizoclones. The rhizoclones have generally been considered as basically monaxonic, but it is possible that at least some forms have arisen from tetracladine spicules of the dendroclone type by development of lateral processes along the main shaft as a consequence of the grouping of the spicules in bundles. This type of development can be seen in some of the spicules of the family Anthracosyconidae, discussed above, the principal spicules of which are tetraclones and dendroclones. A few curved spicules of rhizoclone type have been observed in that family. Gerth (1927, p. 129) reports rhizoclones from the probable anthaspidellid genus *Timorella*, the basic spicules of which are also dendroclones. The occurrence of dendroclones in the rhizomorine *Haplistion* also points up the interrelation of the Rhizomorina and the tetracladine sponges.

Although isolated rhizoclones have been reported apparently from as far back as the Cambrian, the Carboniferous and Permian family Haplistiidae represents the oldest rhizomorine group known from complete sponges. As befits an early stock, the structure of this family is much simpler and more regular than that of the later rhizomorines. The remaining members of this group come from Jurassic and later strata. The reported Paleozoic occurrences of *Cnemidiastrum* are probably erroneous. The genus *Chaunactis* of the Haplistiidae is the earliest known rhizomorine to show some of the specialization of structures of the later forms, namely, the differentiation of incurrent and excurrent surfaces and the presence of a distinct dermal layer. Specialized dermal spicules, however, are known with certainty only from the Mesozoic and later rhizomorines.

INCLUDED FAMILIES: The reader is referred to De Laubenfels (1955, pp. E45–E49) for a list of the included families. To these should be added the Haplistiidae as revised in the present paper.

OCCURRENCE: Cambrian to Recent; worldwide.

FAMILY **HAPLISTIIDAE** DE LAUBENFELS, 1955

Haplistiidae DE LAUBENFELS, 1955, p. E37.

DIAGNOSIS: Massive to foliate sponges with radial architecture; skeletal net regular and open, composed of radial spicule tracts connected by horizontal tracts; tracts composed of rhizoclones, together with dendroclones and smooth monaxons, in parallel orientation; tracts may be hollow or may be cored with smooth monaxons; a specialized dermal net of smooth monaxons may be present.

DISCUSSION: The three genera assigned to this family are separated on the basis of: (1) basic body form, (2) whether or not the fibers are cored, (3) size of radial relative to horizontal fibers, (4) degree of regularity of horizontal fibers, (5) presence or absence of dermal specialization, and (6) presence or absence of differentiated prosochetes and apochetes. Both *Haplistion* and *Kazania* are commonly spheroidal, though *Haplistion* shows subdigitate forms as well. *Kazania* is distinguished by the presence of long oxeas as coring spicules in the tracts, a condition seen in the radial tracts of *Chaunactis* as well, and also is characterized by irregular branching of the horizontal tracts, which is present in some species of *Haplistion*. *Chaunactis* not only is characterized by the presence of coring spicules, but also has a foliate form with differentiated incurrent and excurrent surfaces, as well as a distinct dermal layer. If one may judge from the frequent occurrence of loose oxeas in the mesh spaces of both *Haplistion* and *Kazania*, these genera may also have had a dermal layer but one less highly developed than that of *Chaunactis*. If *Haplistion* also possessed coring spicules, there would be no reason for maintaining *Kazania* as a separate genus. The more highly organized anatomy of *Chaunactis* sets it apart from the other two genera.

De Laubenfels, in establishing this family, included it in the Haplosclerida, on the assumption that *Haplistion* was composed exclusively of smooth monaxons, as it was originally described. The present writer believes, however, as discussed below under *Haplistion*, that this genus possesses rhizoclones, and therefore has revised the family diagnosis accordingly. Besides the type genus De Laubenfels included *Lasiocladia* Hinde, 1884, in the family. This form consists only of a mat of oxeas and is probably a root tuft. It shows nothing like the characteristic structure of *Haplistion*.

INCLUDED GENERA: *Haplistion* Young and Young, 1877 ("*Rhaphidhistia*" Carter, "*Pemmatites*" Dunikowski, "*Pseudopemmatites*" R. H. King, not Fraipont, "*Monarchopemmatites*" De Laubenfels) (Carboniferous to Permian); *Kazania* Stuckenberg, 1895 (Permian); *Chaunactis*, new genus (Pennsylvanian to Permian).

OCCURRENCE: Carboniferous, Permian; Eurasia, North America.

GENUS **HAPLISTION** YOUNG AND YOUNG, 1877

Haplistion YOUNG AND YOUNG, 1877, p. 428. HINDE, 1888a, p. 147.

Rhaphidhistia CARTER, 1878, p. 140.

Pemmatites DUNIKOWSKI, 1884, p. 13. HINDE, 1888b, p. 249. TSCHERNYSCHEW, 1898, p. 6; 1899, p. 9.

Pseudopemmatites R. H. KING, 1943, p. 12 (not *Pseudopemmatites* Fraipont, 1911).

Monarchopemmatites DE LAUBENFELS, 1947, p. 187.

DIAGNOSIS: Form of sponge spherical to lobate, digitate, or irregular; surface hispid because of projecting ends of radial tracts; point of origin of radial tracts commonly eccentric to peripheral, new tracts added by intercalation; spicule tracts compact to hollow, but apparently not cored, and composed of rather straight rhizoclones, with stubby or warty lateral processes, dendroclones, strongyles, and oxeas; the smooth monaxons may be concentrated on the outside of the tracts in some species; no distinct dermal net apparent, but surface may have borne strongyles and oxeas in tangential orientation, or outermost horizontal tracts may expand and fuse laterally on parts of the surface; a few large circular canals may be present, parallel to the radial tracts.

DISCUSSION: The species treated in this paper are differentiated on the basis of: (1) body form, (2) dimensions of the mesh spaces, (3) thickness of the spicule tracts, and (4) the form of the larger canals, if present. Of these characters, the thickness of the tracts appears to be subject to the least amount of variation and has been given preference in the separation of species. There are a large number of species described in the literature which the writer believes to belong to this genus. Most of them have been assigned by their original authors either to *Haplistion* or to *Pemmatites*. The original distinction between the two genera was based on what seemed to be a fundamental difference in spicule type, the tracts of *Haplistion* consisting of smooth monaxons and those of *Pemmatites* of rhizoclones. In all other respects, the descriptions of the two genera show them to be identical. The writer believes that the genotype of *Haplistion*, as do all the well-preserved species studied in the present collections, possesses both smooth monaxons and rhizoclones. An examination of Hinde's original illustration of the type specimen of this species (Hinde, 1888a, pl. 5, figs. 1, 1a, 1b; reproduced here as pl. 27, fig. 3) shows irregular, stubby, lateral projections on many of the spicules, which suggests that they are rhizoclones of the type present in *Pemmatites*. If this is the case, then no distinction can be made between this genus and *Pemmatites*, which thereupon becomes a junior synonym of *Haplistion*. *Rhaphidhistia* Carter was considered by Hinde to be a junior synonym of *Haplistion*. His illustration of the type specimen (Hinde, 1888a, pl. 5, fig. 2a) also shows lateral projections on some of the spicules. Neither he nor Carter was able to isolate the spicules from the tracts. *Pseudopemmatites* King was thought to differ from *Pemmatites* in having tetraclones rather than rhizoclones, because King interpreted the tracts as being the spicules themselves. Examination of the holotype shows that the sponge is composed of tracts of rhizoclones of the *Pemmatites* type, as is described below under *H. skinneri*. The name *Pseudopemmatites* was preoccupied by a hexactinellid sponge described by Fraipont (1911), and King's genus was renamed *Monarchopemmatites* by De Laubenfels (1947). This genus must also be considered a junior synonym of *Haplistion*. Tschernyschew (1898, p. 19) recognized rhizoclones in the two species he assigned tentatively to *Haplistion* (*orientale* and *gruenewaldti*) and proposed to separate *Haplistion* from *Pemmatites* on the basis of the greater length of the processes on the spicules in the former. Because of the differences in preservation of the known species, the present writer does not believe that a separation on that basis can be made with the information now available.

Many of the previously described species assigned here to *Haplistion* were separated on the basis of external form alone. The writer believes that this character is too subject to environmental influence to serve by itself as an adequate means of separation. On the basis of tract thickness and spacing, the known species of the genus can be grouped as follows:

GROUP I: Mesh spaces less than 1.0 mm.; radial and horizontal tracts of approximately equal thickness.

SUBGROUP A: Tracts less than 0.5 mm. in diameter. *Haplistion armstrongi* Young and Young, 1877 (Mississippian), genotype of *Haplistion*.

H. aeluroglossa, new species (Permian).

SUBGROUP B: Tracts about 0.5 mm. in diameter.

H. skinneri (R. H. King, 1943) (Permian), genotype of *Monarchopemmatites*.

SUBGROUP C: Tract diameters not known.

H. verrucosum (Dunikowski, 1884) (Permian), genotype of *Pemmatites*.

H. constipatum (Hinde, 1896) (Mississippian).

GROUP II: Mesh spaces 1.0 mm. or more; horizontal tracts about half of the diameter of the radial tracts (except in *H. orientale* in which they are equal). The species *vermiculatum*, *gruenewaldti*, *orientale*, *megalochetus*, *macropora*, and *artiense* show irregular branching of some of the tracts.

SUBGROUP A: Radial tracts mostly 0.5–1.0 mm. in diameter.

H. vermiculatum (Carter, 1878) (Mississippian), genotype of *Rhaphidhistia*.

H. arcticum (Dunikowski, 1884) (Permian).

H. gruenewaldti (Stuckenberg, 1895) (Permian).

H. orientale (Tschernyschew, 1898) (Permian).

H. timorense (Gerth, 1929) (Permian).

H. sphaericum, new species (Pennsylvanian).

H. megalochetus, new species (Permian).

SUBGROUP B: Radial tracts mostly 1.0–2.0 mm. in diameter.

H. arcticum var. *macropora* (Dunikowski, 1884) (Permian).

H. arcticum var. *latituba* (Dunikowski, 1884) (Permian).

H. artiense (Tschernyschew, 1898) (Permian).

The individual spicules of all these species, where measurements are available, have approximately the same dimensions, averaging 0.5 mm. in length and 0.05 mm. in thickness. The nearly straight shape of the rhizoclones and the shortness of their lateral projections appear to be common to all the species. The presence of smooth oxeas and strongyles in the tracts along with the rhizoclones is probably a generic character. Both types of spicules are present in *aeluroglossa*, *skinneri*, and *sphaericum* of the present collections and were reported from *arcticum;* oxeas alone have been reported from *constipatum*, *gruenewaldti*, and *orientale*. The frequent occurrence of these smooth spicules not only in the tracts but also free in the mesh spaces suggests that some of them were flesh spicules or parts of a dermal layer. *Kazania* Stuckenberg, 1895, is distinguished by the presence of long oxeas as coring spicules in the tracts. *Chaunactis*, new genus, is distinguished chiefly by the differentiation of incurrent and excurrent surfaces on the sponge.

GENOTYPE: *Haplistion armstrongi* Young and Young, 1877 (Mississippian, Scotland).

INCLUDED SPECIES: See the discussion above.

OCCURRENCE: Mississippian: British Isles; Pennsylvanian: New Mexico; Permian: Spitzbergen, Russia, Timor, Texas.

Haplistion aeluroglossa Finks, new species

Plate 19, figures 8–10; plate 26, figures 9–12; plate 27, figures 1, 2

DIAGNOSIS: Flattened-spheroidal to lobate or digitate; tract diameters and mesh spaces small for genus; a few small, circular oscules present, opening into short radial canals; surface strongly hispid.

DESCRIPTION: These are small to medium-sized sponges (maximum dimensions 19–65 mm.) which range in form from flattened-ovoid to lobate and subdigitate. The longitudinal tracts radiate from a point on the base of the sponge; they are connected by horizontal tracts which are not generally at the same level between adjacent tracts. In general both sets of tracts are equally spaced 0.25–0.80 mm. apart, the spacing increasing towards the periphery. Near the basal end the horizontal tracts are more closely spaced than the vertical ones; the radial canals outlined by the horizontal tracts have a quadrate shape. Except near the base, both sets of tracts are cylindrical and approximately equal in diameter, 0.15–0.30 mm. Each tract contains a half dozen, or less, parallel spicules at any one point; the spicules are chiefly rhizoclones but include small curved oxeas and strongyles as well. The tracts are not hollow and have no specialized coring spicules. In some instances the horizontal tracts consist of a single series of superposed spicules and are consequently flattened. Near the base, where the vertical tracts are closer than 0.5 mm., the horizontal tracts are replaced by single dendroclones spaced more or less uniformly 0.08–0.13 mm. apart. The rhizoclones are mostly straight and are as long as the distance from one tract junction to the next. They are 0.3–0.8 mm. long and about 0.05 mm. thick. Some are really dendroclones with a smooth shaft and arborescent terminations; the terminations often consist of three short clads, each of which is bifid. Most of the spicules, however, bear branching projections along one side of the shaft articulating with the adjacent spicule. These spicules are often curved, the smooth concave side facing outward. Some have a branch bearing arborescent processes near one end of the main shaft. Smaller curved rhizoclones commonly round out the angles between tracts. The strongyles are mostly 0.4 mm. long and 0.08 mm. thick; the oxeas 0.40–0.65 mm. long and 0.025–0.080 mm. thick, both being shorter than the desmas. Besides the regular radial intertract spaces, there are a few larger circular oscules 0.8–1.0 mm. in diameter distributed irregularly over the surface; on the subdigitate specimens they occur at the tips of the lobes. The surface of the sponge is hispid because of the projection of the ends of the radial tracts about 0.5 mm. above the surface.

BIOLOGICAL OBSERVATIONS: This species shows particularly clearly the possible relationship of rhizoclones to the dendroclone type of spicule so characteristic of the family Anthaspidellidae. Where the spicules occur singly rather than in bundles, as in the horizontal elements near the base of the sponge, the arborescent processes are developed only at the ends of the shaft, and the spicules are indistinguishable from an anthaspidellid dendroclone. In the bundles, however, articulating processes are developed along the whole length of the shaft, and the spicules have the form of true rhizoclones. The development of the rhizoclone type of desma seems to be related to the grouping of the spicules in bundles. The dendroclones of the tetracladine lithistids are very likely tetraclones in which the cladome is quite short and is mimicked at the opposite end of the rhabdome by secondary processes. This seems to be indicated by types of spicules transitional between dendroclones and tetraclones in the same individual. The spicules of the present species may, however, be basically monocrepid, in which case the dendroclones of this form are not strictly homologous to those of the tetracladine sponges. Such an interpretation is suggested by the presence of true monaxons in the tracts along with the desmas.

The holotype contains two external molds of conularids, probably *Conularia leonardensis* Finks, 1955. (One of these is visible on pl. 27, fig. 1, the specimen referred to in Finks, 1955, footnote p. 833.) Both molds are perpendicular to the upper surface of the sponge and extend well into its interior, so that the sponge must have surrounded the greater part of each individual. The conularids apparently settled on the sponge while it was still alive. It is very possible that this species of *Conularia* was habitually symbiotic on sponges, for similar molds of the same or a related species have been found in the west Texas Permian on specimens of *Defordia defuncta* (see above) and *Guadalupia*, new species (see Finks, 1955), as well as on a sponge in the possession of G. Winston Sinclair (personal communication, 1955).

DISCUSSION: The lobate or digitate specimens of this species resemble *H. verrucosum* (Dunikowski, 1884), the genotype of *Pemmatites*, though the latter is larger in over-all size (compare pl. 27, fig. 7, with pl. 27, fig. 9). The mesh dimensions of the two species are similar, but *H. verrucosum* is unique in having wart-like protuberances on its surface (pl. 27, fig. 8). *Haplistion artiense* Tschernyschew, 1898, also has a digitate form, but its mesh is much coarser. Of the species in the present collection, *H. skinneri* is most similar to *H. aeluroglossa* but has thicker tracts and lacks oscules. The writer considers that mesh dimensions are more reliable guides to specific separation in this genus than is external form, which is more likely to be affected by local environmental conditions. In the present species, external form is more or less consistent at a given locality; the lobate or digitate specimens are confined to A.M.N.H. 503 (U.S.N.M. 703c), the specimen at U.S.G.S. 5713 is flattened and elongate, while those at P.U. 80c are compressed and ovoid. However, the other characteristics of the species, such as tract thickness and spacing, the presence of oscules, and the hispid surface, are consistent in all the specimens, and the writer prefers to consider the differences in growth form as environmentally determined.

MATERIAL: All the specimens are silicified and were prepared with acid. Thirteen specimens were available from the type locality, P.U. 80c, crowded together on a small block with other sponges; four of them were nearly complete individuals, the rest being portions of individuals or inseparable from the matrix. Ten specimens were available from A.M.N.H. 503, one nearly complete, and a few small fragments were recovered from the essentially equivalent U.S.N.M. 703c. A single specimen was found at U.S.G.S. 5713.

OCCURRENCE: *Horizon:* Leonardian. *Localities:* P.U. 80c, U.S.G.S. 5713 (Sierra Diablo); A.M.N.H. 503, U.S.N.M. 703c (Glass Mountains). *Biotopes:* Basin facies (P.U. 80c); mixed basin and patch-reef facies (A.M.N.H. 503, U.S.N.M. 703c); shelf facies (U.S.G.S. 5713). *Lithotopes:* Dark, bituminous, spiculiferous limestone; light bioclastic limestone (U.S.G.S. 5713).

TYPES: Holotype, P.U. No. 78864 (from P.U. 80c); paratypes, P.U. No. 78865, A.M.N.H. No. 28097, U.S.N.M. No. 127634.

Haplistion skinneri (R. H. King, 1943)

Plate 27, figure 5; plate 28, figures 1, 2;
text figures 65–72

Pseudopemmatites skinneri R. H. KING, 1943, p. 16, pl. 3, figs. 10, 12.

Monarchopemmatites skinneri (R. H. King) DE LAUBENFELS, 1947, p. 187.

DIAGNOSIS: Spheroidal; tract diameters and mesh spaces small for genus, but tracts thicker than in *aeluroglossa;* no well-defined oscules.

DESCRIPTION: The two specimens studied are smoothly rounded, elongate, spheroidal sponges. R. H. King (1943, p. 16) notes that in some of the specimens of the type lot the height exceeds the diameter. The larger of the two attains 100 mm. in its maximum dimension. The skeletal net is very dense and strongly radial in organization. Uniformly spaced logitudinal tracts radiate from the base of the sponge and are connected by uniformly spaced concentric layers of horizontal tracts. Both sets of tracts have a similar thickness and spacing, which tend to increase somewhat towards the periphery. The total range of thickness is 0.25–0.60 mm., and the range of spacing is 0.5–1.2 mm. The radial tracts have a quincuncial arrangement, new tracts being added peripherally by intercalation, and at any one level four or five horizontal tracts radiate from each of them. The radial tracts do not project strongly above the surface. Although the surface is smoothly rounded, it bears shallow depressions 4–8 mm. wide and some 2 or 3 cm. apart. The only pores are the circular to polygonal openings, 0.25–1.2 mm. (mostly 0.4–0.7 mm.) in diameter, outlined by the tracts. These continue into radial canals of the same diameter. The tracts are composed chiefly of rhizoclones oriented parallel to the tract axis; they usually bear arborescent processes on one side only, articulating with the neighboring spicule. Some adjacent rhizoclones are connected by short dendroclones oriented at right angles to them. As a result of the separation of the spicules, the tracts have fine pores 0.02–0.15 mm. in diameter. At the junctions of horizontal tracts there are often curved rhizoclones, of which the smooth concave side faces the canal and the convex side bears articulating processes that connect with the tracts. Smooth, slightly curved strongyles also occur among the rhizoclones of the tracts, but they do not seem to be coring spicules. The rhizoclones are generally 0.2–0.5 mm. long and about 0.03–0.05 mm. thick. The strongyles are 0.2–0.4 mm. in length and 0.025–0.050 mm. in thickness. Some smooth curved oxeas, slightly larger than the strongyles, have been found more or less loose in the net; they may also belong to the sponge.

DISCUSSION: This species, known with certainty from only one locality, is closest to *H. aeluroglossa*, new species. It differs in that its tracts are nearly twice as thick, though their spacing is about the same. It also lacks the large oscules of *H. aeluroglossa*, and its surface is less hispid. Of the other species described in the literature, the present form is closest, in tract thickness and spacing, to the genotype, *H. armstrongi*, the over-all form of which is unknown. Among the species of the present collections, this form is unique for the denseness of its skeletal net.

MATERIAL: Two silicified specimens were available for study—the holotype and a topotype. A poorly preserved specimen, U.S.N.M. No. 127635, from U.S.N.M. 707f, has the shape and mesh dimensions characteristic of this species but cannot be identified with certainty.

OCCURRENCE: *Horizon:* Leonardian. *Localities:* U.S.N.M. 709, U.S.N.M. 707f? (Glass Mountains). *Biotope:* Shelf facies. *Lithotope:* Limestone.

TYPES: Holotype, K.U. No. 74167: paratype, K.U. No. 74168; hypotype, U.S.N.M. No. 127636.

Haplistion sphaericum Finks, new species

Plate 25, figures 1–6; plate 26, figures 1–3

DIAGNOSIS: Spheroidal; tract diameters and mesh spaces large for genus; no large radial canals or oscules.

DESCRIPTION: This sponge attains fairly large dimensions and ranges in form from nearly spherical to spheroidal with irregular lateral expansions. The specimens range in diameter from 27 mm. to 100 mm. or more. The architecture of the skeletal net is strongly radial. The longitudinal tracts radiate from the base or from an eccentric point on the interior. They are mostly 0.6–0.9 mm. thick and are spaced 1.5–2.5 mm. apart. The spacing increases somewhat towards the periphery, but new tracts are added by branching or intercalation so that the spacing remains more or less constant. The radial tracts are connected by thinner horizontal tracts, mostly 0.3–0.6 mm. in diameter and spaced 1.8–2.4 mm. apart. The horizontal tracts are not always at the same level in adjacent series. Five or six horizontal tracts frequently radiate in spoke-like fashion from a single point on a radial tract, so that the mesh openings at the surface are often triangular. Many mesh openings, however, are quadrilateral. The ends of the radial tracts project above the surface, so that the sponge is strongly hispid. No large oscules are present. The tracts are bundles of monaxial spicules, oriented more or less parallel to the axis of the tract but somewhat criss-crossed. The spicules are generally straight, 0.02–0.05 mm. thick and 0.25–0.50 mm. long. Many of those seen at the surface are smooth and appear to be oxeas or strongyles, but others bear short lateral processes articulating with the adjacent spicules and are therefore rhizoclones. On some specimens the oxeas or strongyles occur not only on the tracts themselves but also cover the matrix-filled mesh spaces between them. As they are identical to those that make up the tracts, it is not likely that they are foreign, and they may represent a dermal spiculation. It may be that the smooth monaxons are restricted to the surfaces of all the tracts, for the interior parts of the tracts appear to be composed of rhizoclones (see pl. 25, fig. 5). One of the tracts on the holotype bore a single eight-toothed umbel projecting obliquely from the tract. The disc is 0.10 mm. in diameter, and the shaft is 0.05 mm. thick, as are the shafts of the regular spicules of the tracts. Only 0.15 mm. of the spicule is exposed, and it is not possible to say whether a similar umbellate expansion is present at its other end. This spicule may be foreign, although it has the same dimensions as the regular spicules of the tracts and its position is like that of an echinating spicule. It would not be completely anomalous for such a spicule to belong to this sponge, for several living monactinellid (but not rhizomorine) sponges, such as *Myenia* and *Iotrochota*, possess similar birotulate spicules as microscleres. In sections, the tracts appear to be solid rather than hollow and show no specialized coring spicules. Many of the tracts, however, are coarsely silicified and are preserved as hollow tubes of granular silica.

DISCUSSION: This species is closest to *H. megalochetus* of the present collections. The tracts have essentially the same thickness and spacing in the two species, including the thinner nature of the horizontal tracts. The irregularity of the outer parts of the mesh, and the presence of large canals and oscules, in *H. megalochetus* separate that species from the present one. Among the other species described in the literature, *H. arcticum* (Dunikowski, 1884) is closest to the present species, and, indeed, so far as one can tell from the published descriptions and illustrations, the two are nearly indistinguishable (see pl. 26, fig. 4–6). Because the present form is Pennsylvanian and *H. arcticum* Artinskian, it seems desirable to treat the two as separate species, until an examination of specimens of the two forms side by side can be carried out.

MATERIAL: Four wholly or partly silicified specimens were available for study.

OCCURRENCE: *Horizon:* Pennsylvanian (Desmoinesian?). *Locality:* U.S.N.M. 518q. *Biotope:* Pennsylvanian shelf facies? *Lithotope:* Argillaceous limestone.

TYPES: Holotype, U.S.N.M. No. 127632; paratypes, U.S.N.M. Nos. 127633a, 127633b.

Haplistion megalochetus Finks, new species

Plate 28, figures 3–7

DIAGNOSIS: Massive, irregular, possibly encrusting; net predominantly regular and radial, but both radial and horizontal tracts may curve, branch, anastomose, and expand laterally near the outer surface or around the large canals; tract diameters and mesh spaces large for genus; large, somewhat sinuous canals of circular cross section open on upper surface as oscules.

DESCRIPTION: This species is known only from fragments. The sponge was large, probably neither spherical nor foliate, but was possibly partly encrusting in habit. The largest piece is about 40 by 45 by 80 mm. in maximum dimensions. The longitudinal tracts radiate slightly but are largely subparallel. They are 0.4–1.2 mm. (mostly 0.6–0.9 mm.) thick and are spaced 0.9–2.1 mm. apart. They are connected by thinner horizontal tracts 0.2–0.6 mm. thick and 0.9–2.4 mm. apart. The tracts are mostly cylindrical but may be flattened and curved at the junctions; those forming the outer surface or lining the large interior canals are frequently flattened and strap-like. In the vicinity of these surfaces the subrectangular net of the interior becomes very irregular, and the tracts may branch and anastomose. On the single fragment that seems to preserve the outer surface (pl. 28, fig. 7) the superficial horizontal tracts coalesce laterally to form what amounts to a dermal layer. The radial tracts project a millimeter or so above this surface. Many of the tracts appear to show traces of the parallel monaxons that compose them, but the silicification is too coarse for their precise shape to be determined. The tracts are now preserved as hollow tubes of silica, which may or may not reflect the original structure of the tracts. Besides the spaces between the tracts there are larger canals of circular section, 2.5–8.0 mm. in diameter, which cut obliquely through the interior net, curving and branching irregularly.

BIOLOGICAL OBSERVATIONS: On each of two

fragments the sponge has overgrown and surrounded part of a large pelecypod valve, a circumstance suggesting a partly encrusting habit. Small horn corals and auloporoid corals have been found adherent to some of the tracts, often well within the net. In these cases the shells do not interrupt the tracts and may have settled on the skeleton of the sponge following its death. Such was almost certainly true in the case of a small encrusting bryozoan seen on one of the fragments. The large interior canals may represent the position of plant stems or symbiotic worm-like animals, but such a possibility cannot be demonstrated. This sponge occurs in the limestone bioherms of the Wolfcamp formation, which are composed chiefly of brachiopods, sponges (mostly calcareous), Bryozoa, and algae.

DISCUSSION: This species is closest in mesh dimensions to the Pennsylvanian species *H. sphaericum* of the present collections. It differs from that species in lacking a spheroidal form, in possessing large interior canals, and in showing strong irregularities in parts of the net. Irregular branching and anastomosing of the tracts have been observed in other species of *Haplistion*, namely: *H. gruenewaldti* (Stuckenberg, 1895); *H. orientale* Tschernyschew, 1898; *H. artiense* (Tschernyschew, 1898); and *H. vermiculatum* (Carter, 1878). The last of these is closest to the present form in tract thickness and spacing; the small specimens of that species show no canals or oscules.

MATERIAL: All the material is silicified and was prepared with acid. Four large fragments and several smaller ones from the type locality (U.S.N.M. 701c) were probably from a single individual. The specimens from the other nearby localities probably represent this species but do not show the diagnostic large canals. The fragment from the higher horizon, U.S.N.M. 705a, may not belong to this species; its net is somewhat finer.

OCCURRENCE: *Horizons:* Wolfcampian; ?lowermost Leonardian (U.S.N.M. 705a). *Localities:* U.S.N.M. 701, 701a, 701c, 701k; ?705a (Glass Mountains). *Biotopes:* Wolfcampian patch-reef facies; ?Leonardian shelf facies. *Lithotopes:* Biohermal limestone; dolomitic limestone.

TYPES: Holotype, U.S.N.M. No. 127637 (from U.S.N.M. 701c); paratypes, U.S.N.M. Nos. 127638a–127638c.

Haplistion species

Plate 28, figure 8

Virgula sp. GIRTY, 1915, p. 18, pl. 1, fig. 11.

DESCRIPTION: The specimen (U.S.N.M. No. 127639) is a flattened cylindrical fragment 3.0 by 7.0 mm. thick and 15 mm. long. The tracts are pyritized and the mesh spaces filled with clay matrix. The surface openings are rhombic to polygonal, and the tracts are 0.1–0.3 mm. thick and spaced 0.8–1.0 mm. apart. The shape of the spicules cannot be determined beyond the fact that they are monaxons 0.025 mm. in diameter and are in parallel orientation.

DISCUSSION: There can be little doubt that this is a specimen of *Haplistion*, but it is too incompletely preserved to identify specifically. The tract thickness is closest to that of *H. aeluroglossa*, but the mesh spaces are slightly larger. The surface is hispid as in that species, but no oscules are visible. The difference in horizon certainly suggests that it is not conspecific with the Leonardian species. It is by no means related to *Virgula* Girty, 1909 (renamed *Virgola* De Laubenfels, 1955, because of homonymy) which is a Permian calcareous (pharetronid) sponge.

OCCURRENCE: Desmoinesian (Wewoka formation), a calcareous shale of the Pennsylvanian shelf facies, U.S.G.S. 2006 green (Oklahoma).

CHAUNACTIS FINKS, NEW GENUS

DIAGNOSIS: Foliate or flabellate sponges with differentiated incurrent and excurrent surfaces; radial tracts originating at base of sponge and dichotomizing upward; tracts loose and open, composed chiefly of irregular rhizoclones in non-parallel orientation, and either hollow or cored with long, smooth monaxons; specialized dermal layer present, which may be composed of a rectangular net of bundles of parallel monaxons; prosochetes and apochetes parallel to horizontal tracts and differentiated from each other by size, shape, or spacing.

DISCUSSION: Only one species of this genus is well enough preserved to be adequately characterized. However, the three forms included here can be separated, so far as they are known, on the basis of: (1) relative size, shape, and spacing of the prosopores and apopores, (2) size of mesh spaces, (3) thickness of spicule tracts, and (4) nature of the dermal layer. The spiculation is not well known, because the individual principal spicules of the skeletal tracts are completely fused with one another. They seem to be irregularly curved monocrepid desmas which are probably rhizoclones. The great similarity of the skeletal net to that of *Haplistion*, the spicules of which are clearly rhizoclones, strengthens this interpretation. The open, porous nature of the tracts appears to be a generic character and separates this genus from *Haplistion* and *Kazania*. Oxeas coring the radial tracts were seen only in *C. foliata*, but this feature may well be generic also; it is found in *Kazania* but not in *Haplistion*. The foliate shape of *Chaunactis*, with the attendant differentiation of incurrent and excurrent sides, separates it from the other two genera of the family. A dermal layer of some sort is likewise peculiar to the genus, but the rectangular mesh seen in *C. foliata* may be characteristic of that species alone.

GENOTYPE: *Chaunactis foliata*, new species (Missourian; Texas).

INCLUDED SPECIES: *Chaunactis foliata; Chaunactis*, species 1; *Chaunactis*, species 2.

OCCURRENCE: Missourian (Texas); Guadalupian (Texas, Mexico).

Chaunactis foliata Finks, new species

Plate 28, figures 9, 10; plate 29

DIAGNOSIS: Flabellate to auriform, thin, with beveled edge; mesh spaces small for genus; radial tracts cored with long, smooth monaxons; dermal net a one-layered, rectangular mesh of tracts of small monaxons, parallel to the interior net but with spaces one-fourth as large; prosopores and apopores circular to elliptical and closely spaced, the apopores apparently somewhat smaller than the prosopores.

DESCRIPTION: This sponge consists of thin fronds with a relatively narrow base and a convex upper margin. They are generally curved laterally so as to be somewhat auriform, are 6–10 mm. thick, sometimes thinner towards the free edge, and stand 25–30 mm. high. The largest specimen was originally more than 30 mm. high and more than 60 mm. wide. The skeletal net includes longitudinal spicule tracts which radiate from the base of the sponge towards its upper margin in layers parallel to the broad sides. They are connected by somewhat thinner concentric tracts within each layer. Both sets of tracts have nearly the same relative positions in successive layers, so that they outline circular canals perpendicular to the flat sides. These canals pass through most of the thickness of the sponge, but it is not clear whether they are continuous from one surface to the other. They are bowed slightly towards the upper edge of the sponge and have nearly continuous walls which connect the layers of tracts. The radial tracts are 0.2–0.6 (mostly 0.4) mm. thick and are spaced 0.7–1.2 mm. apart. New tracts are added peripherally both by dichotomy and by intercalation. The concentric tracts that connect them are mostly 0.2–0.4 mm. thick and 0.6–1.8 mm. apart. The successive layers are somewhat more closely spaced than the tracts within each of them; the layers may also dichotomize upward. The large canals open on both broad surfaces in circular pores 0.3–1.2 mm. in diameter. Those on the concave surface, which are possibly the apopores, are on the average slightly smaller than those of the opposite side, but the difference is not pronounced. The exact shape of the spicules which make up the tracts cannot be determined. They appear to be curving monocrepid desmas 0.08–0.20 mm. thick and some 0.25–0.50 mm. long. They outline more or less circular spaces 0.10–0.35 mm. in diameter, and as a result the tracts are highly porous. The longitudinal tracts appear to be cored by large, smooth oxeas 0.05–0.15 mm. thick and at least 0.3 mm. long. On some of the specimens extensive patches of an outer dermal layer are preserved on the broad sides. This is a single layer of a rectangular mesh, parallel to the interior skeletal mesh but much finer. The longitudinal tracts of this dermal mesh are 0.02–0.05 mm. thick and about 0.2 mm. apart; the horizontal tracts have the same thickness but are spaced more widely, 0.2–0.4 mm. apart. Each of these tracts consists of two or three monaxonic spicules side by side; the spicules are 0.01–0.02 mm. thick, and those of the longitudinal tracts may be more than 0.8 mm. long. Where this dermal layer continues over the upper edge of the sponge, it loses its rectangularity and outlines irregularly arranged circular pores 0.05–0.65 mm. in diameter.

DISCUSSION: The characters of this Pennsylvanian species are quite consistent in the five known specimens. They differ from the Permian forms assigned to this genus in their smaller over-all size, in the thinner tracts and finer mesh, and in the relative lack of differentiation between the pores of one broad side and those of the other. The fine dermal mesh has not been observed in the other two species, but it may have been present. Coring monaxons have likewise not been seen in the later forms, but the size and arrangement of the desmas in the tracts of *Chaunactis*, species 1, are very similar to those of the present species.

MATERIAL: Five calcified specimens, weathered out of shale, were available for study. Three thin sections were made from U.S.N.M. No. 127641a.

OCCURRENCE: *Horizon:* Missourian (Gaptank formation, bed 10). *Locality:* U.S.N.M. 700 (Glass Mountains). *Biotope:* Pennsylvanian shelf facies. *Lithotope:* Calcareous shale.

TYPES: Holotype, U.S.N.M. No. 127640; paratypes, U.S.N.M. Nos. 127641a–127641d.

Chaunactis, species 1

Plate 30, figures 1–6

DESCRIPTION: This sponge occurs in the form of curving sheets. One specimen appears to have been formed by the amalgamation of two or three such sheets; it also bears irregular depressions on one surface, suggesting a possible semi-encrusting habit. The sheets are 7–20 mm. thick, and their maximum dimensions are in the vicinity of 100 mm. Both broad sides are covered by a dermal layer. That on the convex, presumably incurrent, side is pierced by large circular pores, 0.6–1.5 mm. in diameter separated by spaces 0.6–1.2 mm. wide. Fine circular pores 0.05–0.2 mm in diameter cover the intervening areas. The concave, presumably excurrent, surface bears closely spaced, subpolygonal pores, 0.6–1.2 mm. in diameter separated by spaces only 0.4–0.7 mm. wide. Their pattern bears no obvious relation to that of the interior tracts and canals. The areas separating these pores are pierced by small pores 0.05–0.13 mm. in diameter. The radial tracts are nearly parallel to one another and run parallel to the broad sides. They are approximately 0.6 mm. in diameter and spaced 1.5–1.8 mm. apart. They are connected by more slender and widely spaced tracts about 0.4 mm. thick and 1.8–3.0 mm. apart. The tracts are hollow and composed of anastomosing, twisted, strand-like bodies, presumably the spicules, which are 0.07–0.13 mm. in diameter and at least 0.8 mm. long. The silicification is too coarse for the precise form of the spicules to be determined, but they appear to be some sort of monocrepid desma. No coring spicules are preserved. No spicules are preserved in the dermal layer.

DISCUSSION: The general form of this sponge is similar to that of *C. foliata*, though it is a bit larger. In the dimensions and spacing of the tracts, this species is intermediate between *C. foliata* and the much coarser *Chaunactis*, species 2. The difference in shape and spacing between the prosopores and the apopores sets this form apart from *C. foliata* in which the two types are little differentiated. On the other hand it does not show the large oscules characteristic of *Chaunactis*, species 2.

MATERIAL: Four silicified fragments were prepared with acid. They bear Y.P.M. No. 19607.

OCCURRENCE: The specimens are from an argillaceous, dark limestone of Guadalupian (Cherry Canyon) age near La Difunta, Coahuila, Mexico, Y.P.M. 25.

Chaunactis, species 2

Plate 31, figures 1–3

DESCRIPTION: This form is known from a few coarsely silicified fragments of what appears to be a large, sheet-like sponge. The largest piece is 15 mm. thick and about 60 mm. square. One flat side is covered with a dense dermal layer, less than 1 mm. thick, which is pierced by large, circular oscules 2–5 mm. in diameter and 5–12 mm. apart. The oscules are frequently surrounded by a slightly raised rim. The surface between the oscules is pierced by many small pores 0.2–0.4 mm. in diameter and 0.6–0.9 mm. apart. The opposite surface lacks a dermal layer, and the interior tracts are exposed there, the canal spaces between them opening as subcircular pores. The longitudinal tracts, which run parallel to the flat sides, are very nearly parallel to one another, radiating slightly towards one end. They are 0.6–1.2 mm. thick and spaced 1.8–2.4 mm. apart. They are connected in the plane of the flat surfaces by tracts of similar thickness, running at right angles to them, which are slightly more widely spaced, 2.4–3.6 mm. apart. The canal spaces between them are perpendicular to the presumed incurrent surface, but curve and narrow towards the excurrent side, to which they are almost tangential. The walls of these canals are more or less solid, pierced only by circular pores 0.2–1.2 mm. in diameter, which connect them with the adjacent canals, presumably between the successive layers of tracts. The connections of these canals to the oscules could not be seen. The oscules themselves, however, lead into canals of the same diameter which run perpendicularly at least halfway into the interior. Presumably they connect with the spaces between the tracts. In one instance, a horizontal canal, running just under the dermal layer, leads into the oscular canal; it is peculiar in that it is not parallel to the tracts. The tracts themselves are finely porous, with circular openings 0.07–0.10 mm. in diameter which may represent the spaces between the spicules. No spicules can be discerned.

DISCUSSION: The specimens are so coarsely silicified that it is impossible to determine the finer structure of this sponge. The arrangement of the tracts is typical of the genus as is the general form of the sponge. The tracts are coarser and more widely spaced than in the other two species, and it is unique in having a dense dermal layer with large and widely spaced oscules.

MATERIAL: Two large fragments and five smaller pieces were available for study; all bear Y.P.M. No. 19605.

OCCURRENCE: Y.P.M. 192, Word limestone number 4 (Guadalupian), Glass Mountains.

SUBORDER **EUTAXICLADINA** RAUFF, 1893

DIAGNOSIS: Principal spicules dicranoclones; architecture of sponge radial or concentric.

DISCUSSION: As set up by Rauff, this category included two families, the Astylospongiidae and the Hindiidae. Both possess dicranoclones, that is, stout tetraxonic desmas in which the fourth arm is much reduced. In the latter family the spicules are regularly arranged in concentric layers, with the three long rays directed proximally; in the former the spicules are not uniformly oriented and there are apparently six long rays instead of three. De Laubenfels, in his revision of the family (1955, pp. E60–E63), subsumed the Hindiidae in the Astylospongiidae, added Rauff's family Chiastoclonellidae, and erected two new families for some Mesozoic and later forms. In the present writer's opinion the original separation between the Astylospongiidae[1] and the Hindiidae should be maintained. De Laubenfels' two new families, the Gignouxiidae and the Pseudoverruculinidae, are most closely related to the Hindiidae, differing chiefly in body form and in the presence of additional types of spicules, especially in the dermal layer. The dicranoclones of the Gignouxiidae are very similar to those of the Hindiidae; those of *Pseudoverruculina*, which is the sole genus in its family, are peculiar. The Chiastoclonellidae belong to the Tetracladina, in which Rauff originally placed them. De Laubenfels, however, assigned to that family four genera that are certainly eutaxicladines and that are most similar to the Astylospongiidae. They should probably be placed in that family or else in a new family which would be analogous to the Gignouxiidae in its relation to the Hindiidae.

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[1] The present writer disagrees with the nomenclature of the astylosopongiids given by De Laubenfels (1955, pp. E60–61). Rauff (1894), in establishing the family, recognized but three genera, namely, *Astylospongia* Römer, 1860; *Caryospongia* Rauff, 1894; and *Carpospongia* Rauff, 1894. The corresponding names ending in *-manon*, which he established at that time, were specifically stated by him (Rauff, 1894, p. 313) *not* to represent true genera, but were rather "*Quasi-Geschlechtsnamen*" which were to be subsumed under the corresponding generic names ending in *-spongia*. If, however, the former be regarded as separate genera, as De Laubenfels did, then *Astylomanon* Rauff, 1894, must yield to *Palaeomanon* Römer, 1860, of which it is a junior *objective* synonym. The three genera recognized by Rauff were separated on the basis of the distribution of the apopores, *Astylospongia* having them concentrated in a depression at the top of the sponge, *Caryospongia* having them confined to meridional grooves, and *Carpospongia* having them uniformly distributed over the whole surface. De Laubenfels, in combining *Caryospongia* with *Carpospongia* and separating them from *Caryomanon-Carpomanon*, unfortunately substituted for this consistent arrangement a vague reference to the external form of the sponge.

The gignouxiids, and probably *Pseudoverruculina* also, are almost certainly descendants of the Paleozoic hindiids. Their dicranoclones generally lack a distal ray, a development that had already taken place in the late Paleozoic with the origin of *Scheiia.*

INCLUDED FAMILIES: Astylospongiidae (Ordovician–Silurian; ?Cretaceous–Recent); Hindiidae (Ordovician–Permian; ?Cretaceous); Gignouxiidae (Jurassic–Cretaceous; ?Recent); Pseudoverruculinidae (Cretaceous).

FAMILY **HINDIIDAE** RAUFF, 1893

Hindiadae (*sic*) RAUFF, 1893, p. 327.
Microspongiidae HOWELL, 1940, p. 45.

DIAGNOSIS: Massive, dominantly spheroidal sponges composed of concentric layers of dicranoclones having three proximal rays with broad, concave, terminal expansions and arranged in subparallel orientation; no dermal specialization.

DISCUSSION: The four genera that seem to belong to this family differ chiefly in the degree of development of the distal ray and of the tuberculate ornamentation on the spicules. *Neohindia* differs from the others in body form, being stalked and having a cloaca. Because of its shape as well as because of its occurrence in the Mesozoic, it might better be placed in the Gignouxiidae, which are almost certainly the descendants of the Paleozoic hindiids. On the grounds of stratigraphic occurrence *Ozotrachelus* might also be placed in the Gignouxiidae.

The name of the present family was changed to Microspongiidae by Howell in 1940, in accordance with the then current International Rules of Zoological Nomenclature, when Howell recognized *Microspongia* Miller and Dyer, 1878, as a senior synonym of *Hindia* Duncan, 1879. Subsequently, at the Copenhagen Congress (1953) the Rules were amended so as to require retention of the original family name when the name of its type genus is changed because of synonymy (Hemming, 1953, p. 36, par. 54). The family name must therefore revert to Hindiidae, whatever one's opinion may be regarding the synonymy of *Hindia* and *Microspongia.* The writer prefers to retain the name *Hindia* for that genus, agreeing with the arguments put forth by Ulrich as early as 1890. Ulrich (1890, pp. 228–229) recognized the probable identity of the two genera but pointed out that the type specimens of *Microspongia* were even at that time apparently lost, that the original description of the genus and species was inadequate to distinguish it from other genera of similar external form and was incorrect with respect to the form of the spicules, and that the name *Hindia* had been widely used for the genus since the time of its publication. Ulrich, therefore, preferred to regard *Microspongia* as unrecognizable, although he noted that the only spheroidal sponges known to him from the type locality of *Microspongia* were true *Hindia,* and that he had seen topotype material of *Microspongia* identified by Miller which were identical to *Hindia.* Howell (1940, p. 45) relied on these facts in synonymizing the two genera, and also stated that Bassler had personally informed him that he had seen the types of *Microspongia* and considered them congeneric with *Hindia.* Inasmuch as *Hindia* has certainly been the more widely used of the two names, particularly by those authors, such as Hinde and Rauff, who have most thoroughly described the genus, and inasmuch as the types of *Microspongia* appear to be lost and have never been adequately described in the literature, the present writer is retaining the name *Hindia* in this paper.

INCLUDED GENERA: *Hindia* Duncan, 1879 (Ordovician–Devonian); *Scheiia* Tschernyschew and Stepanov, 1916 (Carboniferous–Permian); ?*Neohindia* Schrammen, 1901 (Cretaceous); ?*Ozotrachelus* De Laubenfels, 1955 ("*Pachytrachelus*" Schrammen, 1910, not Chaudoir, 1852) (Cretaceous). The last two genera may be better placed in the family Gignouxiidae.

GENUS **SCHEIIA** TSCHERNYSCHEW AND STEPANOV, 1916

Scheiia TSCHERNYSCHEW AND STEPANOV, 1916, p. 4.

DIAGNOSIS: Dicranoclones lacking a distal ray; entire distal surface of each spicule covered with spherical tubercles.

DISCUSSION: At present it is difficult to recognize more than one species in this genus. If species are to be separated in the presently known material, it should probably be done on the basis of spicule size and possibly the presence or absence of differentiated large apopores.

The genus is distinguished from its closest relative, *Hindia*, by the total absence of a distal ray on the spicules and by the presence of tubercles on the entire distal surface of the spicule. Because of the lack of the distal ray, the terminal expansions of the proximal rays articulate directly with the centrum of the underlying spicule rather than with the inner portions of its proximal rays as in *Hindia*. In the known examples of *Scheiia* the proximal rays are stouter than those of *Hindia*. The spicules of *Ozotrachelus* also lack a distinct distal ray, but the centrum is much more swollen than in *Scheiia* and tubercles are confined to this part of the spicule. The writer has not seen illustrations of the spicules of *Neohindia*, but its body apparently is vasiform rather than spheroidal.

Genotype: *Scheiia tuberosa* Tschernyschew and Stepanov, 1916.

Occurrence: Mississippian of Ireland?; Permian (Arctic Canada, Russia, Timor, Texas).

Scheiia tuberosa Tschernyschew and Stepanov, 1916

Plate 32, figures 1–7; plate 33, figures 1, 7

Scheiia tuberosa Tschernyschew and Stepanov, 1916, p. 6, text figs. 1–4, pl. 1, figs. 1–7, pl. 2, figs. 1–4.

Hindia permica Gerth, 1927, p. 98, pl. 2, fig. 2, pl. 3, figs. 3, 3a, 4.

Hindia permica var. *bitauniensis* Gerth, 1927, p. 100, pl. 1, fig. 8, pl. 3, figs. 2, 2a.

Hindia wanneri Gerth, 1927, p. 100, pl. 2, fig. 7, pl. 3, figs. 1, 1a, 1b.

? *Hindia pumila* Hinde, 1888a, p. 157, pl. 5, figs. 8, 8a–f.

Diagnosis: Spherical to bun-shaped; centrum of spicule triangular in outline and gently convex distally, proximal rays short, thick, and essentially straight, terminal expansions equidimensional and subpolygonal in outline; oscules and ostia present in addition to skeletal pores.

Description: This sponge is typically a smooth-surfaced sphere, but some may have irregular depressions on the surface or be hemispherical with an indented base. The diameters of the present specimens range from 34 to 74 mm. The skeletal pores are circular, 0.15–0.40 mm. in diameter, the average diameter generally increasing with the size of the sponge. Larger circular ostia are also present, 0.4–0.8 mm. in diameter and 1.5–3.0 mm. apart. On some specimens still larger circular oscules, 1–2 mm. in diameter, may be present; they are irregularly distributed, and the maximum number found on a single specimen was eight. The interior has a strictly radial structure, the point of radiation being at the center of the sponge in the spherical specimens and at the center of the base in the hemispherical specimens. A large central hollow, sometimes occupying more than a fourth of the diameter, is often present in the spherical individuals. The pores lead into radial canals of the same diameter; new canals are intercalated peripherally. Each of the smaller canals is surrounded by three vertical rows of spicules; the larger ostial canals by more, generally six. As a result, they have a subpolygonal outline, and each of the sides is perforated by a vertical row of pores 0.05–0.08 mm. in diameter between the superposed spicule rays. The pores of adjacent sides are arranged at alternate levels.

The spicule is a triclad dicranoclone with the three rays directed obliquely downward. The centrum is only slightly swollen and only slightly wider than the rays. The end of each ray bears a concave face of subpolygonal outline, slightly broader than the ray shaft, which fits over one-third of the centrum of the spicule below. The upper surface of the centrum and rays, as well as the entire margin of the terminal expansion of each ray, is covered with closely set spherical tubercles. The spicules are arranged in concentric layers, alternating in position in successive layers, so that the distal surface of each centrum is in contact with one ray from each of three overlying spicules. The rays of each spicule are 0.2–0.3 mm. long and 0.08–0.13 mm. thick, their distal ends are 0.15–0.20 mm. in diameter, the centrum is 0.10–0.20 mm. in diameter, and the tubercles are 0.01–0.25 mm. in diameter. No axial canals could be seen in thin section. No other types of spicules are present.

Discussion: The spicules of the four species listed in the synonymy are essentially the same as those of the present material, so far as can be told from the published descriptions and illustrations. The only consistent difference observed is the fact that the spicules of *S. wanneri* (Gerth) are less than half as large as those of the others in sponges of comparable size. This may indicate a valid specific difference, but thin-section study of the variability shown by a large suite of topotypes would be necessary to prove it. The present specimens are the only ones known to possess large oscules, though ostia are present in all the species except *S. pumila* (Hinde) which is known only from isolated spicules. The three species that are known from complete individuals all show departures from strictly spherical form in some specimens; the hemispherical, bun-shaped form is seen in the single specimen of *S. wanneri* (Gerth) as well as in some of the present material. It is likely that these variations in growth form are due to environmental conditions. It may be that the bun-shaped specimens rested on the sea floor in one spot, while the strictly spherical individuals were continually rolled about by movements of the water. One of the hemispherical specimens in the present collections has incorporated shell fragments into its base, which indicates its attachment to a shelly bottom (see pl. 33, fig. 7). No trace of attachment can be seen in the spherical sponges. The present species can be easily distinguished from *Haplistion skinneri*, which often has a similar appearance, by the spicules.

MATERIAL: Twenty-two silicified specimens were available for study in the present collections. Thin sections were made from one of the specimens.

OCCURRENCE: *Horizon:* Leonardian. *Localities*: Guadalupe Mountains: A.M.N.H. 666; Glass Mountains: A.M.N.H. 500, U.S.N.M. 702, 702b. *Biotopes:* Patch-reef and basin facies. *Lithotopes:* Light and dark limestones.

The type material of *S. tuberosa* is from the Artinskian limestones at both Big Bear Cape, King Oscar's Land (Ellesmere Island), Canada, and at Krasnoufimsk in the Ural Mountains, Soviet Union. The two species of Gerth are from Timor, Indonesia, particularly the Artinskian beds at Bitauni, the probably Kungurian beds at Basleo, and the probably Kazanian beds in Amarassi. *Scheiia pumila* (Hinde) is known only from isolated spicules from the Mississippian limestones at Ben Bulben, Sligo, Ireland.

HYPOTYPES: A.M.N.H. Nos. 28072, 28072:1, 28072/1; U.S.N.M. Nos. 127643a–127643c.

DEMOSPONGEA, *INCERTAE SEDIS*

ISOLATED DEMOSPONGE SPICULES

Insoluble residues from several localities have yielded isolated non-lithistid spicules of tetraxonic form. The triaene types could have been dermal spicules of lithistid sponges, although no lithistid sponge in the collections shows such spicules in place. They probably belong to non-lithistid sponges, as is almost certainly the case with the spicules of calthrops type. Various kinds of monaxonic spicules have also been found, which may be from demosponges or from hexactinellids. These monaxons are described in another part of this paper under isolated lyssacine spicules. The following are the chief types of isolated tetraxons that have been found.

CALTHROPS (PL. 33, FIG. 3): Both spinose and smooth, equal-armed tetraxons were recovered from U.S.N.M. 703c. They range in total diameter from 0.2 mm. to 1.0 mm. Smooth spicules of similar form occur at A.M.N.H. 369, and spiny calthrops occur at U.S.G.S. 2969 green, 6660, and 6674.

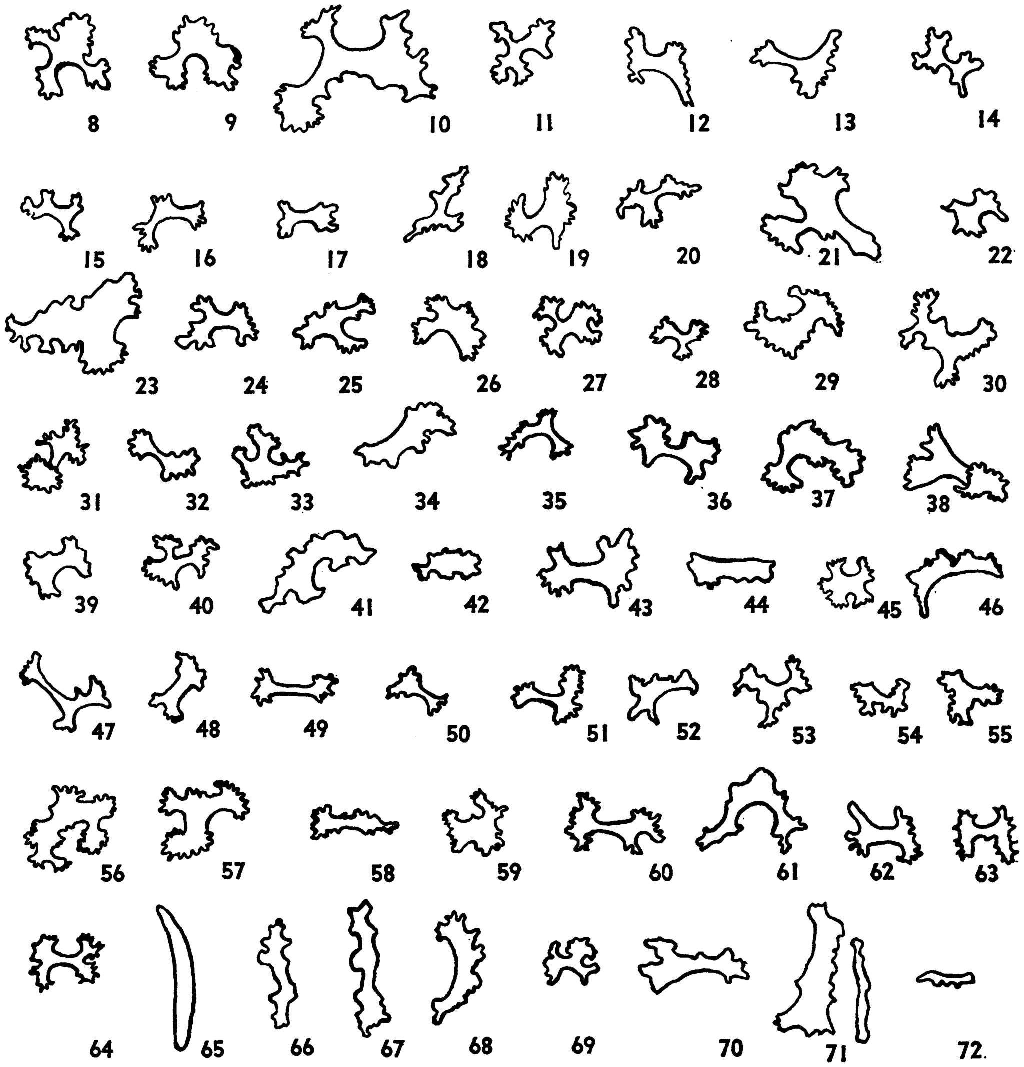
PROTRIAENES (PL. 33, FIG. 2): Smooth protriaenes up to 0.5 mm. in cladome width and 1.2 mm. in rhabdome length occur at P.U. 80c; A.M.N.H. 503, 512; and U.S.N.M. 703c. The clads make an angle of about 150 degrees with the rhabdome.

ANATRIAENES: Smooth anatriaenes, of similar dimensions to the above-mentioned protriaenes, were found at P.U. 80c; U.S.G.S. 2915 green, 6660, 6674; and U.S.N.M. 703c. The clads make angles of about 30 degrees with the rhabdome.

CLASS HEXACTINELLIDA SCHMIDT, 1870

DIAGNOSIS: Skeleton of hydrous silica with individual spicules built about three perpendicularly intersecting axes; spongin absent; living tissue an open syncytial net, without mesoglea, in which a layer of flagellated chambers is embedded.

DISCUSSION: This class is divided by zoologists into two orders (Amphidiscophora and Hexasterophora) based on the form of the microscleres. Because microscleres are very rarely preserved in fossils, the commonly ac-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FIGS. 8–72. Lithistid spicules. 8–20. *Defordia defuncta* King, from U.S.N.M. 705a, Leonard formation. 8–10. U.S.N.M. No. 127604k. 11–14. U.S.N.M. No. 127604g. 15–20. U.S.N.M. No. 127604j. 21–26. *Defordia densa* Finks, new species. 21–23. P.U. No. 78871, from P.U. 77, Bone Spring limestone. 24–26. P.U. No. 78867, from P.U. 1rc, Bone Spring limestone. 27–30. *Defordia* species cf. *D. densa* Finks, new species, U.S.N.M. No. 127607a, from U.S.N.M. 707q, Leonard formation. 31–35. *Defordia* species, U.S.N.M. No. 127610, from U.S.N.M. 707q, Leonard formation. 36–38. *Actinocoelia maeandrina* Finks, new species, U.S.N.M. No. 127611, from U.S.N.M. 749, San Andres formation. 39, 40. *Jereina ramosa* Finks, new species, U.S.N.M. No. 127617, from U.S.N.M. 707e, Word formation. 41–44. *Anthracosycon ficus* Girty, U.S.N.M. No. 118127, from U.S.G.S. 2920 green, Bone Spring limestone. 45–50. *Anthracosycon regulare* (King), K.U. No. 74147, from U.S.N.M. 707q, Leonard formation. 51–55. ?*Collatipora pyriformis* Finks, new species, U.S.N.M. No. 127629, from U.S.N.M. 703c, Word formation. 56–59. *Dactylites micropora* Finks, new species, P.U. No. 78881, from P.U. 80c, Bone Spring limestone. 60–64. *Dactylites subdigitatus* Finks, new species, P.U. No. 78880, from P.U. 3e, Bone Spring limestone. 65–72. *Haplistion skinneri* (King), from U.S.N.M. 709, Leonard formation. 65–69. U.S.N.M. No. 127636. 70–72. K.U. No. 74167.

Outline drawings made from photographs. All are approximately 40 times natural size.

cepted paleontological classification separates the orders by the manner in which the megascleres are united in the skeletal net. Of these orders, the Lyssakida include all the Amphidiscophora and the suborder Lyssacinosa of the Hexasterophora. The Dictyida and the Lychniskida correspond to the remaining suborders of the Hexasterophora. De Laubenfels (1955) also includes the Order Heteractinida Hinde, 1888a. In the opinion of the present writer this group should be referred to the Class Calcarea, with the exception of *Hyalostelia* Zittel and possibly of *Tholiasterella* Hinde, which are lyssacines.

ORDER **LYSSAKIDA** ZITTEL, 1877

DIAGNOSIS: Spicules not fused together or else fused in such a way that the limits of each spicule are apparent.

DISCUSSION: The superfamilies and families of this order are separated chiefly on the basis of the general architecture of the skeletal net and of the fundamental form and degree of differentiation of the principal spicules.

PROTOSPONGIOIDEA FINKS,
NEW SUPERFAMILY

DIAGNOSIS: Globular to vasiform, sometimes prismatic, sponges with a thin body wall; skeleton composed of simple hexacts or reduced derivatives of hexacts, of one or more orders of size and in one or more layers; if the spicules are uniformly oriented, their parallel rays commonly overlap; in some forms stout, continuous bundles are formed from greatly elongated overlapping rays; monaxial prostalia frequently present; root tuft commonly present.

INCLUDED FAMILIES: Protospongiidae (Cambrian–Silurian); Teganiidae (Ordovician, Permian); Dictyospongiidae (Devonian–Permian); Stereodictyidae (Permian); Hyphantaeniidae (Devonian–Carboniferous).

DISCUSSION: This group has been set up to include the family Protospongiidae together with those families that represent but slight modifications of its basic structural plan. This structural plan is the simplest and most generalized one to be found among the Hexactinellida, consisting of a thin-walled, sac-like body supported by a single layer, or a very few layers, of unmodified spicules. In the Protospongiidae proper, the spicules are simple stauracts arranged in a single layer. The fact that nearly all the Cambrian hexactinellids, as well as the majority of the Ordovician ones, can be referred to this family suggests that we are dealing with something close to the basic stock of the whole class. Such a conclusion is further strengthened by the fact that embryos of more complex living hexactinellids, for example, those of *Farrea sollasii* described in Okada, 1928, have the same structure and spiculation. As in the living embryos, the Protospongiidae probably had an ascon architecture in which the choanocytes formed a continuous single layer lining the large central cavity.

The Dictyospongiidae may be considered a direct development from the protospongiid type. The layer of stauracts is finer meshed and more regular, the body form more elaborate, parietal gaps are uniformly absent, and more than one spicule layer is present in the body wall. Connected with the last-named feature is the presence of spicule types other than stauracts, or their grouping into differentiated structural elements, such as bundles of spicules, or reticulate lamellae perpendicular to the surface. Possibly a revision of the dictyospongids will show that some of these more elaborate skeletal types should be placed in separate families. According to Hall and Clarke (1899) the dictyosponge skeleton is differentiated into a coarse-meshed inner layer made of horizontal and vertical bundles of monaxons, and a finer-meshed outer layer of stauracts. *Hyphantaenia* Vanuxem appears to be constructed of this inner layer alone and, unlike other members of the family, appears to possess large parietal gaps. De Laubenfels erected a new family, the Hyphantaeniidae (1955, p. E76) to accommodate this genus, which was included by Hall and Clarke in the Dictyospongiidae. De Laubenfels also includes the dictyospongiid *Physospongia* Hall in the same new family, interpreting its characteristic protuberances as covered parietal gaps.

The new family Stereodictyidae, established in the present paper, may represent another offshoot from the dictyosponge stock, in which the skeleton has come to consist entirely of monaxon bundles. In this form the number of layers in the body wall has been multiplied, so that it has become quite thick, and a third set of radial bundles has been added to the vertical and horizontal ones.

The tendency to form a thicker body wall seems to have developed during the late Paleozoic in the main dictyosponge stock itself. The new Permian genus *Microstaura* described below as a member of the Dictyospongiidae, is almost identical externally to that most primitive of the dictyosponge genera, *Dictyospongia* itself. It differs in that the body wall is several spicule layers thick, consisting not of stauracts but of hexacts arranged in a uniform cubic mesh. From this type of three-dimensional structure, in which parallel spicule rays overlap but do not fuse, it is but a simple step to the continuously fused dictyonine skeleton, which first appears in the middle Triassic.[1] It seems quite possible that the cubic-meshed Dictyonina, or some of them, originated in this way from dictyospongiid ancestors.

Quite another line of development from the protospongiid stock may have led to the group of genera for which De Laubenfels (1955, p. E70) established the family Teganiidae. These forms have retained the globular shape of the primitive protospongiids, but the spicules tend to lose their regular quadratic alignment and parietal gaps interrupt the mesh. In addition, there is a strong development of radially arranged monaxons which project some distance from the surface of the sponge. All the genera referred to this family by De Laubenfels are restricted to the Ordovician system. There is a remote possibility that the middle Cambrian genera *Choia* Walcott and *Hamptonia* Walcott represent teganiids in which only the radial monaxons have been preserved. A more likely member of the group is the new Permian genus *Polylophidium*, described in this paper, the body plan and general form of which agree with those of the Ordovician representatives of the family. One must not discount the possibility that all the species referred to this family may be juvenile forms of hexactinellids with strong root tufts.

The middle Cambrian genus *Vauxia* Walcott, the skeleton of which consists exclusively of spicules resembling stauracts with one ray missing, may represent a specialized offshoot of the Protospongiidae. It may also be related to the Brachiospongioidea and the Euplectelloidea in which similar triactinal spicules occur. It was assigned to a family of its own by De Laubenfels (1955, p. E77).

FAMILY **DICTYOSPONGIIDAE** HALL, 1884[2]

DIAGNOSIS: Vasiform, sometimes prismatic with eight sides, often with symmetrically arranged protuberances; body wall very thin and without parietal gaps; main skeleton differentiated into an outer, very fine, and regular quadrate mesh of stauracts overlying an inner, coarser, quadrate mesh of vertical and horizontal bundles of monaxons; hexacts and more elaborate spicules may be present as well as monaxonic prostalia.

DISCUSSION: The bipartite division of the body wall into an inner layer of spicule bundles and an outer layer of uniformly sized hexact derivatives in parallel orientation seems to be the basic structural plan of this family. Otherwise, there seems to be no strong dermal specialization. Hall and Clarke (1899, p. 32) describe small umbellate clavules and complex pinnulate spicules from the dermal layer of the well-preserved specimens at Crawfordsville, Indiana. These tiny spicules have not been preserved on the majority of dictyosponge specimens. The absence of parietal gaps would also seem to be an important diagnostic feature.

The genera in this family have been separated chiefly on the basis of external shape, together with other features of the gross morphology.

The two species referred here to this family partake of its general structural organization, though the walls have become thicker than in the earlier dictyosponges. *Endoplegma calathus*, however, possesses parietal gaps. If we assume that the typical dictyosponge body plan and external shape, which it shows, truly indicate a genetic relationship, then we must also assume a late development of parietal gaps in the dictyosponge line.

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[1] *Tremadictyon roemeri* and *Caesaria* sp. as cited by Rauff (1937, p. 12), both from the German Muschelkalk.

[2] Hall states (1884, p. 465) that the plates from the 1884 report, which were printed with the explanations in 1882 under the title of "Notes on the family Dictyospongiae" (*sic!*), and communicated to the annual meeting of the American Association for the Advancement of Science in Montreal, were "not communicated for publication." According to this statement by Hall, therefore, the name was not truly published until 1884.

INCLUDED GENERA: The reader is referred to De Laubenfels (1955, pp. E71–E76) for a list of the genera included in the family. Three of those he lists should, however, be removed from the family. *Cyathodictya* Hall and Clarke, 1899, is an incorrect renaming of *Cyathophycus* Walcott, 1879. As Hall and Clarke themselves indicated (Hall and Clarke 1899, pp. 23 ff.) this genus belongs in the family Protospongiidae, in which, indeed, De Laubenfels had included it under its earlier name. So far as the present writer is aware, De Laubenfels was incorrect in citing a Silurian and Devonian age for the genus; the only known species is Ordovician. *Sphaerodictya* Hall and Clarke, 1899, should also be removed. This genus is a junior synonym of *Teganium* Rauff, 1894, as is discussed below under the family Teganiidae. The Devonian age cited by De Laubenfels for *Sphaerodictya* is erroneous; it is also Ordovician. *Acanthodictya* Dawson and Hinde, 1889, from the Ordovician of Canada, probably belongs to the Protospongiidae and may be identical to *Cyathophycus*, with which it occurs.

The new genus *Microstaura* Finks is here added to the family, and the new genus *Endoplegma* Finks is added provisionally.

OCCURRENCE: Devonian to Permian; Europe and North America.

SUBFAMILY **PRISMODICTYINAE**
DE LAUBENFELS, 1955

Prismodictyinae DE LAUBENFELS, 1955, p. E74.

DIAGNOSIS: "Prismatic forms with polygonal transverse section, generally eight-sided" (De Laubenfels, 1955, p. E74).

DISCUSSION: De Laubenfels' subdivision of the family into genera with and without a prismatic shape points up possible relationships between certain genera, but it probably does not reflect a complete division of the dictyosponges into two lines of descent.

MICROSTAURA FINKS, NEW GENUS

DIAGNOSIS: Cylindrical to subprismatic, with broad osculum; moderately thin-walled main skeleton a uniform cubic mesh of very small hexacts; no parietal gaps or canals larger than regular mesh spaces; no specialized dermalia or gastralia except for suppression of distal rays.

DISCUSSION: In its external form and in the size of its spicules, this genus closely resembles the simplest of the Devonian dictyosponges. It also possesses the characteristic body plan of the family, with an inner layer of monaxon bundles, in this case only vertical ones, and an outer layer of strictly parallel hexacts. It differs from the Devonian forms in that the outer layer has been thickened by development of more than one layer of hexacts. In retaining their strictly parallel orientation, these hexacts form a cubic mesh which resembles a dictyonine skeleton, differing in the lack of a tip-to-tip fusion of the spicules. There is no dermal specialization.

GENOTYPE: *Microstaura doliolum*, new species. This is the sole species.

OCCURRENCE: Leonardian; west Texas.

Microstaura doliolum Finks, new species

Plate 34, figures 1–14

DIAGNOSIS: Small sponge; juveniles barrel-shaped and lacking root tuft; adults moderately elongate, smooth-surfaced cylinders or weakly developed prisms, possibly bearing a long root tuft; root tuft, if present, composed of bundles of long, smooth, slender monaxons which may extend longitudinally for some distance within body wall of sponge.

DESCRIPTION: The form of the sponge is essentially cylindrical, but with a pronounced contraction at both the oscular and basal ends. The smaller, presumably juvenile, individuals are shorter relative to their width, so that they are barrel-shaped or, in the case of the tiniest, very nearly globular. The largest specimens are incomplete, but, where preserved, the basal end is distinctly conical. Some of the specimens are obscurely prismatic, but it is not possible to determine the number of prism faces. All the specimens have been crushed, so that their present maximum width is greater than the original diameter. In their present condition the smallest individual is 3.4 mm. wide and 3.5 mm. high, and the largest reasonably complete one is 10 mm. wide and 58 mm. high. Where measurable, the body wall ranges in thickness from 0.4 mm. in the smallest individual to 2.0 mm. in one of the larger fragmental specimens. The skeleton is composed almost entirely of smooth, slender-rayed hexacts; those on the cloacal and exterior surfaces lack the outer ray. Most of the spicules are of approximately the same size in a given individual, the diameter (tip-to-tip) ranging from 0.2–0.4 mm. in the smaller specimens to 0.8–1.0 mm. in the larger. They are in parallel orientation, with the rays of adjacent spicules usually overlapping almost completely, so that the mesh spaces enclosed by them is approximately one-half of the total diameter of a spicule (i.e., 0.1–0.5 mm.). In the larger specimens a second order of spicules can be recognized which are half of the size of the others and divide the primary mesh spaces into equal quadrants. Three orders of size may be present in the largest individuals. The thickness of each spicule ray of whatever size is roughly one-tenth of its length and tapers only slightly from crossing to tip. Three of the specimens from A.M.N.H. 675 show in places a series of vertically oriented bundles of spicules; each bundle is 0.1–0.5 mm. thick. Their spacing coincides with the primary mesh, but it does not seem likely that they are bundles of the usual hexacts, as there is no corresponding series of horizontal bundles. They are probably groups of monaxonic spicules which may form part of the main skeleton of the sponge as in the dictyosponge *Lyrodictya* Hall, 1884, or else may be an extension of root-tuft spicules into the sponge body. The existence of a root tuft in the present species is questionable. None has been found attached to any of the specimens; however, at A.M.N.H. 675 a separate fragment of a root tuft (pl. 34, fig. 13) was found with the specimens under discussion. The smooth monaxons making up this tuft appear to be somewhat thinner than any of the rays in the associated sponges.

The specimens from A.M.N.H. 675 are crushed quite flat on the bedding surfaces, and it is not possible to determine the wall thicknesses or indeed to prove that any of the spicules visible are hexacts rather than stauracts. The specimens from the type locality (U.S.N.M. 703c), on the other hand, are preserved in three dimensions, having been dissolved from the matrix with acid. On these it can be seen that the mesh is quite regularly cubic. In their present condition the spicule rays are lightly fused side to side. It is not possible to say how much of this fusion was original, though the secondary coating of granular silica visible in plate 34, figure 1, is almost certainly due to diagenetic processes.

BIOLOGICAL OBSERVATIONS: A considerable suite of individuals of different sizes is available from both localities. The close association of the individuals at each locality, as well as the essentially identical nature of the spicules and skeletal net, makes it likely that we are dealing with a single species. Certain characters, however, show a gradual change from the smaller specimens to the larger. These presumably ontogenetic changes include a development in shape from a nearly globular form through a barrel shape to an elongate cylinder with a conical apex. Another change involves the addition of larger orders of size of spicules; the smallest specimens have a single order of spicules of approximately 0.2 mm. in diameter; larger specimens have both a 0.2-mm. and a 0.4-mm. set; the largest have three size orders of 0.2-mm., 0.4-mm., and 0.8-mm. diameters as well as a few spicules of still larger size. The globular form of the small specimens is typical of the juvenile condition of recent hexactinellids, even those of which the adults have a quite different shape (see Okada, 1928). Much of the subsequent growth probably involved simple addition to the oscular end of the sponge which would account for the conical shape of the lower end of the large forms as well as their relative increase in length. However, the contracted nature of the oscular end of the small sponges would seem to require an expansion of this part of the skeleton with further growth, probably involving a pulling apart of the spicules (which could not therefore have been fused together) and an intercalation of spicules of the next larger order of size.

This species has been found at only two localities, both of the basin facies. The delicate nature of the skeleton suggests that they could have lived only in quiet water. At A.M.N.H. 675 the larger specimens have all been more or less torn, despite what was probably very minor post-mortem disturbance. The presence of individuals of various sizes within a circumscribed area at each locality implies relatively little transportation prior to burial.

DISCUSSION: Apart from the greater thickness of the body wall, the form of this species is essentially that of *Dictyospongia* or *Prismodictya*, the most generalized of the dictyosponges. It also resembles the protospongiid *Cyathophycus* which, however, appears to possess parietal gaps not found in the true dictyosponges. It is perhaps not surprising that one of the latest representatives of the family should be so generalized, for it is a common pattern of evolution in many animal groups for the primitive basic stock to survive or persist alongside its more specialized descendants. (A parallel example is the Permian fish *Palaeoniscus*, very similar to the earliest paleoniscoid, the Devonian *Cheirolepis*.) The thickening of the body wall may have been a trend in many dictyosponge lines of descent, as witness the genera *Endoplegma* and *Stereodictyum* described below. It is hard to compare the spicules of the present form with those of the earlier dictyosponges, because the limits of individual spicules in the main skeleton of the latter have rarely been determined. Hall and Clarke were of the opinion (1899, p. 29) that the finest reticulation was formed by an outer layer of overlapping stauractins (they used this term in a broader sense than we do today, including not only stauracts but also pentacts and hexacts, as can be seen from their last footnote on p. 22) and that the larger quadrules were formed by an inner mesh of vertical and horizontal bundles of monaxons (see also their fig. 3, p. 20). However, the preservation of their material in most cases obscured the limits of the individual spicules, and only the size of the mesh spaces could be measured. The present specimens are more fortunately preserved, and the size of the largest spicules corresponds approximately to the finer meshes measured by Hall and Clarke. The larger orders of quadrules do not show up on the present specimens. Those at A.M.N.H. 675 do show an inner layer of monaxon bundles, but these are spaced no more widely than the main mesh and consist of vertical bundles only. Apparently, therefore, the fineness and uniformity of the mesh distinguish the present species from other dictyosponges.

It must be pointed out that the specimens from A.M.N.H. 675 are from a somewhat lower horizon and show certain differences from those at the type locality, U.S.N.M. 703c. The vertical monaxon bundles were not found in specimens from the latter locality. Also the sponges from A.M.N.H. 675 appear to have a thinner body wall, though this cannot be stated with certainty because of the different mode of preservation. Because of these differences in preservation as well as the fact that the larger specimens are all incomplete, it seems unwise to make a taxonomic separation of the collections on the basis of the present material.

MATERIAL: From U.S.N.M. 703c: 10 specimens, including five complete juveniles and five more or less fragmental larger individuals. All were silicified and prepared with acid. From A.M.N.H. 675 about 30 individuals crushed flat on weathered bedding surfaces, siliceous but containing some unknown dark material. They include about 20 juveniles on one slab as well as 10 more or less fragmental larger specimens on two other slabs; there is also a root-tuft fragment on a fourth slab.

OCCURRENCE: *Horizon:* Leonardian. *Localities:* Glass Mountains, U.S.N.M. 703c; Delaware Mountains, A.M.N.H. 765. *Biotopes:* Basin facies (A.M.N.H. 675); mixed basin and patch-reef facies (U.S.N.M. 703c). *Lithotopes:* Slabby, dark, spiculiferous limestone (U.S.N.M. 703c); slabby, dark, spiculiferous, limy siltstone (A.M.N.H. 675).

TYPES: Holotype, U.S.N.M. No. 127648 (U.S.N.M. 703c); paratypes, U.S.N.M. Nos. 127649a–127649i (U.S.N.M. 703c), A.M.N.H. Nos. 28073, 28073:1–28073:3 (A.M.N.H. 675).

ENDOPLEGMA FINKS, NEW GENUS

DIAGNOSIS: Vasiform, prismatic or subprismatic with broad osculum and moderately thick body wall bearing large circular parietal gaps; dermal layer composed of moderately large smooth pentacts, uniformly oriented to form a regular quadrate mesh; interior skeleton containing long monaxons oriented longitudinally and transversely.

DISCUSSION: This genus has the basic body plan of the dictyosponges, with an inner layer of vertical and horizontal monaxon bundles covered by a single outer layer of pentacts in parallel orientation. Its external shape is also a characteristic prismodictyine one, resembling very closely, with its single whorl of eight nodes, the Mississippian genus *Tylodictya*. However, the whole skeleton is much coarser, with generally larger and somewhat more loosely organized elements, than that of the typical dictyosponges. Furthermore, well-developed parietal gaps are present, though partly concealed by the outer layer. Because its most fundamental features are dictyospongid, the differences are here considered to be the result of evolutionary developments from earlier and more typical forms.

Endoplegma resembles the new species decribed below as *Carphites diabloensis* in its general spiculation and organization of the body wall, differing in the finer nature of the dermal spicules, in the lack of triacts, and probably also in external shape, which is not known in *Carphites*. *Carphites diabloensis* is connected through a complete series of forms with *Docoderma*, which has been assigned to a separate superfamily, the Brachiospongoidea. It seems best to retain *Endoplegma* in the Dictyospongiidae in the present state of our knowledge.

GENOTYPE: *Endoplegma calathus*, new species. This is the sole species.

OCCURRENCE: Leonardian; west Texas.

Endoplegma calathus Finks, new species

Plate 35, figures 1, 6–11

DIAGNOSIS: Large, subprismatic, expanding upward and bearing whorl of eight low protuberances near oscular end; base broad; parietal gaps partly concealed by dermal pentacts of two size orders; interior skeleton and cloacal lining composed entirely of monaxons grouped in strap-like bundles.

DESCRIPTION: The species is known with certainty only from a single specimen which is a rather large individual strongly flattened by compaction in the sediment. It is in the form of a rather squat beaker or goblet, narrowest immediately above the broad base and broadest about two-thirds of the way up, whence it narrows slightly to the rim of the wide osculum. It is 130 mm. high and, in its present flattened condition, 109 mm. wide at the widest part and 80 mm. at the narrowest. The compressed dimension is 20–25 mm. The widest portion bears a horizontal row of eight low, rounded elevations, 10–15 mm. in diameter and 30–40 mm. apart. Each elevation appears to be on the crest of an obscure vertical angulation which extends for some distance down the side of the sponge and suggests a poorly developed prismatic form. The outer surface is covered with a single layer of large, smooth-rayed pentacts of two orders of size in subparallel arrangement. Only a few of these have been preserved entire; the rest are preserved as molds on the underlying, coarsely silicified interior spicules. The larger are arranged quincuncially, with the tip of each ray touching the tips of three adjacent rays so as to outline a square mesh space as wide as the length of one ray. The smaller spicules, when present, are half of the size of the larger and divide these primary mesh spaces into four quadrants. The larger pentacts increase in size from 4 mm. in diameter and 0.2 mm. in ray thickness near the base to 12 mm. in diameter and 1.0 mm. in ray thickness near the upper end. The resultant primary mesh spaces vary from 2 mm. at the lower end to 6 mm. at the upper end; the secondary meshes vary likewise from 1 mm. to 3 mm. All the dermalia were apparently quite free and not fused to one another. The body wall is 10 mm. thick at the upper end of the sponge. Its internal structure is obscured by considerable siliceous replacement, but it appears to be composed entirely of broad, strap-like bundles of long, smooth monaxons, which also form the sole spiculation of the cloacal surface. The bundles are arranged roughly in vertical and horizontal groups, paralleling the rays of the dermal spicules, though they are much broader than the spicule rays. Those immediately beneath the dermal layer appear to accompany the dermal spicule rays as comitalia. Individual monaxons are 0.08–0.25 mm. in diameter and are at least 25 mm. long in some places. There is a suggestion, near the base of the sponge, that some of these bundles may have protruded from the surface as a root tuft, possibly in a circular frill about the truncated base as in the Devonian *Thysanodictya* Hall and Clarke. Unfortunately the basal end is poorly preserved, and its structure is obscure.

The body wall is pierced by numerous large parietal gaps of circular outline. Their external openings are from 1.5 mm. to 6.0 mm. in diameter; the corresponding cloacal openings may be as great as 11 mm., two or three adjacent exterior gaps in some instances having a common cloacal opening. The external gaps may be larger than the dermal mesh spaces, and in such cases they are traversed by a ray or rays of the dermal pentacts with their accompanying comitalia. The gaps are always outlined by the interior monaxon bundles which curve around them.

DISCUSSION: The basic structural plan of this sponge, with its thin outer layer of pentacts over an inner layer of vertical and horizontal monaxon bundles, agrees with Hall and Clarke's original definition of the family Dictyospongiidae. The whorl of protuberances and subprismatic shape also recall the form of many dictyosponge genera; indeed, the shape of the present specimen resembles that of *Tylodictya warrenensis* Hall and Clarke (1899, p. 151, fig. 18). However, the general construction is coarser and less regular than that of other dictyosponges: the dermal pentacts are larger, the interior monaxon bundles broader and less regularly arranged, and the whole body wall is much thicker. In addition, the presence of parietal gaps is a feature specifically excluded from the family diagnosis. Without a better knowledge than is available at present of the structure of both the typical dictyosponges and the present species, it is not possible to determine the significance of these similarities and differences. The species is provisionally included here among the Dictyospongiidae. The present form also resembles the new genus *Carphites*. Unfortunately the latter has been found only as fragments, so that no comparisons of over-all form can be made. The general construction of *Carphites*, however, consists similarly of an outer layer of large, simple pentacts over a thick interior layer of obscurely horizontal and vertical spicule bundles, with similar large parietal gaps. *Carphites* differs in that the interior spiculation consists chiefly of peculiar triacts the three rays of which are in the same plane, two along a common axis and the third at an acute angle; it is these triacts which form the interior bundles. Such spicules could not be seen in *Endoplegma*. The specimens of *Carphites plectus* from the same locality as the present species contain only these triacts in the interior. The specimens of *C. diabloensis* at P.U. 1r have, in addition, strap-like bundles of long monaxons as in *Endoplegma*. *Carphites plectus* differs further from *Endoplegma* in that the dermalia are frequently hexacts with a short distal ray, rather than true pentacts; the rays are also somewhat stouter, and extra rays in the dermal plane are occasionally developed. On the basis of the presence of the special triacts, as well as the tendency to develop extra dermal rays, *Carphites* has been assigned to the new family Docodermatidae. *Endoplegma* could not fit into that family as presently diagnosed, but it cannot be denied that the specimens of *Carphites diabloensis*, so far as they are preserved, are structurally intermediate between the two genera. A solution of this problem must await better material.

From the same locality as that of the present specimen come several smaller forms, more poorly preserved, which may belong to this species. One is a fragment (pl. 35, fig. 1) with dermalia essentially the same as in the holotype, but the interior of which is completely obscured by granular silica. It is listed as a paratype. The others are more or less entire small forms of similar preservation, which may be juveniles of the present species but which differ in several respects. They are described below as "Lyssacine, species 2?"

MATERIAL: From U.S.N.M. 703c: one nearly entire specimen and one fragment, both silicified and prepared with acid.

OCCURRENCE: *Horizon:* Leonardian (Word limestone number 1). *Locality:* U.S.N.M. 703c. *Biotope:* Mixed basin and patch-reef facies. *Lithotope:* Dark, platy, bituminous, spiculiferous limestone.

TYPES: Holotype, U.S.N.M. No. 127651; paratype, U.S.N.M. No. 127650.

STEREODICTYIDAE FINKS, NEW FAMILY

DIAGNOSIS: Skeleton composed of three sets of spicule bundles interlacing at right angles to one another; each bundle consists of parallel monaxons or of reduced derivatives of hexacts with greatly elongated rays.

DISCUSSION: The skeletal structure exemplified by this family is unique among sponges. As in the dictyonines, it is a true three-dimensional, rectangular net, but the elements of the net are bundles of parallel spicules rather than the rays of individual hexacts. Each bundle maintains its identity where it crosses others, although the rays of some of the constituent spicules may enter and participate in the transecting bundle. The form of the individual spicules is obscure;

most may be very long monaxons, but at least some appear to have three or more rays and participate in two or three bundles, their crossings being located at the bundle intersection.

Only one species is included in this family, but its structure, as outlined above, warrants family separation. It can be readily understood as a development from the family Dictyospongiidae by hypertrophy of the inner layer of the body wall and loss of the outer layer of stauracts. The interior of the body wall in most dictyosponges consists of a two-dimensional net of horizontal and vertical spicule bundles. By the development of other such layers, concentric to the first, and by the addition of radial bundles at right angles to them, the structure of the present form can be attained. This method of forming a thick body wall from the basic dictyosponge structure differs from that seen in the new genus *Microstaura*, in which the outer layer of stauracts is expanded into a cubic mesh of separate hexacts, a development capable of leading directly to the dictyonine condition.

INCLUDED GENUS: *Stereodictyum*, new genus (Permian).

OCCURRENCE: Permian; Texas.

STEREODICTYUM FINKS, NEW GENUS

DIAGNOSIS: Vasiform sponge, the body wall of which consists of alternating layers of vertical and horizontal spicule bundles, with radial bundles lodged in the mesh spaces made by these two sets.

DISCUSSION: The characters arbitrarily selected here for the generic diagnosis relate to the manner in which the skeleton is put together out of separate layers of parallel bundles (see fig. 73).

GENOTYPE: *Stereodictyum orthoplectum*, new species.

OCCURRENCE: Wolfcampian, Leonardian; west Texas.

Stereodictyum orthoplectum Finks, new species

Plate 37, figures 1–8; plate 38, figures 1–7;
text figure 73

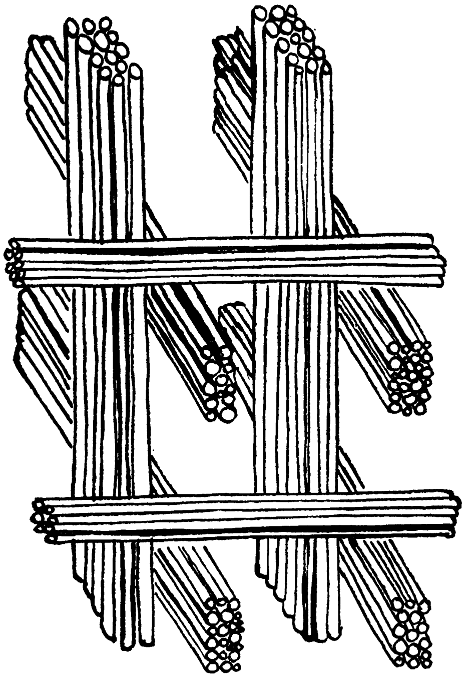


FIG. 73. *Stereodictyum orthoplectum* Finks, new species. Diagram of part of sponge wall showing alternate layers of vertical and horizontal spicule bundles, with smaller radial bundles crossing them perpendicularly; the cloaca is towards the left and the osculum towards the top.

DIAGNOSIS: Large, upwardly flaring cone; wall thickness less than half of sponge radius; spicule bundles approximately equally spaced, but wider spaces at regular intervals occupied by radial canals of circular cross section, connected by similar annular canals; each spicule bundle contains about a dozen spicules in any one cross section.

DESCRIPTION: No entire individual is known, but all the fragments appear to be parts of elongate cylinders or cones that tend to flare outward slightly towards one end, presumably the upper. The most nearly complete specimen, which is one of the smaller individuals, must have been originally more than 100 mm. in height and from 30 mm. to 40 mm. in diameter; its body wall is 5 mm. thick (pl. 37, fig. 1). It is narrowest at the presumed basal end, expands in a gentle, convex curve, and finally flares outward again. The holotype (pl. 37, figs. 3–6) is from a very much larger individual; the body wall is 45 mm. thick, and, if we assume the curvature of this fragment to remain the same around the whole circumference, the diameter of the sponge must have been about 220 mm.; by analogy with the smaller specimen it may have been nearly 700 mm. high. Other large fragments show so slight a curvature that we must assume that they come from parts of the sponge body that do not have a perfectly circular cross section, for, if the same curvature were maintained about a full circle, its diameter would be in excess of a meter. The thickness of the body wall varies greatly in these fragments, from 2 mm. to 45 mm., though most are in the vicinity of 10 mm. In even the thickest specimens the cloaca occupies most of the diameter of the sponge. No root tuft is known.

The body wall is composed of successive layers, in mutual contact, of parallel bundles of spicules, a layer of longitudinal bundles alternating with one of annular bundles. The bundles of corresponding layers occupy the same relative positions, so that the rectangular interspaces, outlined by the crossing of the two sets, form canals which pass radially through the wall. These spaces are partly occupied by a third set of radial bundles. Additional radial bundles are apparently intercalated peripherally where the circumference is greater. The longitudinal and annular bundles are of approximately equal diameter (0.2–0.6 mm.) and somewhat flattened in the plane of the layer. The radial bundles are smaller and less compressed (0.1–0.3 mm.). The longitudinal bundles are more or less evenly spaced in each layer, 0.5–1.5 mm. apart. The annular bundles are more closely spaced, 0.4–0.9 mm. apart, so that the interspaces are elongate horizontally. As a rule, a radial bundle occupies each end of the interspace. However, an annular bundle is commonly lacking after every three or four, so that there are horizontal rows of larger and squarer interspaces, with a radial bundle at each corner. The longitudinal bundles are also lacking at somewhat greater intervals, so as to form vertical rows of still larger spaces, each of these occurring where a gap in the longitudinal series intersects one in the annular series. These larger canals, which are 0.5–1.0 mm. in diameter, tend to have a circular cross section. None has been traced completely through the wall, and possibly those opening on the exterior are incurrent canals which have no direct connection with the similar excurrent canals opening on the gastral surface, except through the fine spaces of the mesh. There are, however, annular canals of a similar size which must connect some of the adjacent radial canals; the annular canals are somewhat more numerous near the cloacal surface. Each spicule bundle is composed of a dozen or so individual spicules the rays of which are 0.015–0.130 mm. in diameter. The form of these spicules could not be ascertained. They appear to be very long monaxons, but thin sections (pl. 38, figs. 6, 7) show connections of individual rays with those in intersecting bundles. These connections seem to take place most frequently in an inward or downward direction. Whether they represent secondary deposits about independent monaxons or the spicules are hexacts with some rays missing cannot be determined. In either case, the directions of the connections suggest that the sponge grows by adding layers of bundles both upwardly and peripherally.

No dermal or gastral specialization has been observed in this species. Furthermore, no consistent occurrence of either a longitudinal or an annular set of bundles on a given surface, dermal or gastral, could be demonstrated.

Biological Observations: The variability in wall thickness is probably a reflection of ontogenetic stage. It is likely that the wall increases in thickness by addition of layers to the external surface, and that the sponge increases in height by extension of the longitudinal bundles and addition of annular ones. Such a method of growth is suggested by the fact that interconnections between transecting bundles most commonly take place inwardly and downwardly, that is, between bundles that are already present at a given stage of development. As the sponge increases in diameter upward, additional longitudinal bundles must be intercalated between those already present. A similar intercalation of radial bundles must certainly take place in a peripheral direction, as the same spacing is maintained despite an increase in circumference. A local dislocation of the net, probably owing to an injury, was observed on the cloacal surface of the holotype (see pl. 37, fig. 6). This is the only hexactinellid besides *Stioderma coscinum* that occurs outside the basin, or mixed basin and patch-reef, facies.

Discussion: This species first appears in the *Uddenites*-zone of the Glass Mountains section. This zone is probably the lowermost bed of the Wolfcamp formation (G. A. Cooper, personal communication). Fragments of the sponge are very common in the succeeding shaly beds of the Wolfcamp. They also occur in the interbedded biohermal limestones, as well as in the stratigraphically equivalent limy beds of the Hess facies, and in the Hueco limestone of the Sierra Diablo. *Stereodictyum* next appears in the near-shore facies of the basal Bone Spring formation in the Sierra Diablo and is present at a single basin-facies locality (A.M.N.H. 369) in the middle Bone Spring formation of the Guadalupe Mountains. The delicacy of the specimens at the latter locality suggests that they were not transported far before burial, which is the only indication that this sponge lived in the marginal basin, as well as the shelf, environment. A single occurrence is known from the Leonardian Cibolo limestone of the Chinati Mountains, but the facies and the exact horizon are unknown. No occurrences of *Stereodictyum* are known from the Leonard formation of the Glass Mountains. Were it not for the sporadic occurrences in Leonardian rocks, this species could be considered a guide fossil to the Wolfcampian series. However, the presence of numerous specimens of this species in a rock is at least suggestive of a Wolfcampian age. No consistent differences were observed between the Wolfcampian and Leonardian examples that would permit a specific separation.

MATERIAL: About three dozen silicified fragments and about 10 calcified ones were available for study. Three oriented thin sections of a calcified specimen from U.S.G.S. 7001a were made.

OCCURRENCE: *Horizons:* Wolfcampian, including *Uddenites*-zone (Glass Mountains, Sierra Diablo); Leonardian (Sierra Diablo, Guadalupe Mountains, Chinati Mountains). *Localities:* Glass Mountains: U.S.N.M. 701, 701a2, 701c, 701z, 702h, 706x; U.S.G.S. 5874, 7047; Y.P.M. 87, 88, 89, 93, 95, 168, 175, 198 222. Sierra Diablo: A.M.N.H. 628, 629; U.S.G.S. 7001a, 7004, 8543; Y.P.M. 478. Guadalupe Mountains: A.M.N.H. 369. Chinati Mountains: A.M.N.H. Cibolo Creek. *Biotopes:* Shelf facies, near-shore facies, basin facies; Wolfcamp shale facies, Wolfcamp patch-reef facies. *Lithotopes:* Calcareous shales, light shelf limestone, biohermal limestones, dark limestones.

TYPES: Holotype, U.S.N.M. No. 127654 (from U.S.N.M. 701a2, Wolfcamp formation); paratypes, U.S.N.M. Nos. 127655, 127656, 127657, 127658, A.M.N.H. Nos. 28077, 28077:1, Y.P.M. Nos. 19594, 20201.

FAMILY **TEGANIIDAE** DE LAUBENFELS, 1955

Teganiidae DE LAUBENFELS, 1955, p. E70.

DIAGNOSIS: More or less globular, thin-walled sponges composed of simple hexacts, or reduced derivatives of hexacts, not regularly arranged; parietal gaps small and numerous; well-developed monaxial prostalia and basalia present.

DISCUSSION: This family is a not altogether satisfactory grouping of several forms, most of them poorly preserved, which have in common a nearly globular shape and the presence of long, radially disposed monaxons projecting from the surface. All the included forms resemble the protospongiids in their simple spiculation and thin body walls. They differ from the protospongiids in the non-parallel arrangement of the spicules. The writer has amplified De Laubenfels' diagnosis (1955, p. E70) to include the last-named feature, as well as the presence of parietal gaps, which distinguishes the teganiids from the dictyospongiids. It is possible that all the species assigned here may prove to be juvenile stages of lyssacines of somewhat different shape, for a globular form is characteristic of many young hexactinellids.

Only *Teganium* and *Polylophidium* are known from well-preserved material. The three genera of Ruedemann are from the same locality as *Teganium*, but they differ from the other members of the family in having a more elongate shape. One of these genera, *Polyplectella* Ruedemann, is the only genus besides *Polylophidium* to have the protruding monaxons grouped into tufts. Two Cambrian genera of Walcott, *Hamptonia* and *Choia*, which were each assigned to new families of the Demospongea by De Laubenfels (1955, pp. E39, E42), may belong to the Teganiidae. They consist only of radiating masses of monaxons, and resemble the interior spiculation of *Polylophidium* in which the outer layer of hexacts has been stripped away. However, no hexacts have been found with the Cambrian forms, and their tentative inclusion here must be considered only a possibility.

A word needs to be said concerning the name of the type genus of this family. The genotype and sole species of *Teganium* Rauff, 1894, is *Cyathophycus subsphaericus* Walcott, 1879. Neither the holotype of Walcott nor the topotypes used by Rauff in redescribing the species show much detail of the skeletal structure. Hall and Clarke subsequently examined additional material from the type locality which had the same external form but showed the spicular structure much more clearly. It is on Hall and Clarke's illustrations of these specimens (1899, pl. 1, figs. 18–22) that the present writer has based his understanding of the genus and the family. Hall and Clarke point out (1899, pp. 24–26) that there is no assurance that these specimens have the same structure as those studied by Walcott and Rauff. They therefore propose the new generic name *Sphaerodictya* for the specimens which they studied. Unfortunately, they chose *Cyathophycus subsphaericus* Walcott as genotype (Hall and Clarke, 1899, p. 200), thereby making their new genus a junior objective synonym of *Teganium* Rauff. Until Hall and Clarke's material can be restudied and a new genus and species based on it, it seems best to assume that Hall and Clarke's material represents examples of *Teganium subsphaericum* (Walcott) and retain the generic name *Teganium* for it.

INCLUDED GENERA: ?*Choia* Walcott, 1920 (Cambrian; North America); ?*Hamptonia* Walcott, 1920 (Cambrian; North America); *Teganium* Rauff, 1894 (Ordovician; North America); *Polyplectella* Ruedemann, 1925 (Ordovician; North America); *Foerstella* Ruedemann, 1925 (Ordovician; North America); *Sycodictya* Ruedemann, 1925 (Ordovician; North America); *Polylophidium*, new genus (Permian; North America).

POLYLOPHIDIUM FINKS, NEW GENUS

DIAGNOSIS: Body wall composed of simple hexacts with stauracts and pentacts on the outer surface; interior occupied by bundles of long, smooth monaxons radiating from the center of the sponge and projecting from the surface as numerous tufts; much larger root tuft formed in similar manner.

DISCUSSION: The presence of radial monaxons occupying most of the interior of this sponge separates it from the Ordovician forms, in which the radial monaxons appear to be confined to the outer layer. At least this is so in Hall and Clarke's specimens of *Teganium* ("*Sphaerodictya*") *subsphaericum;* the other Ordovician species are poorly preserved. The grouping of the protruding parts of the monaxons into separate tufts also distinguishes this genus from all the Ordovician forms except *Polyplectella* Ruedemann, which differs from the present form in having an elongate rather than globular shape. The outer layer of hexacts in the present form, though still quite thin, appears to be somewhat thicker than the corresponding part in the Ordovician forms. None of the Ordovician genera, except possibly *Polyplectella*, bears a root tuft as in the present form. The poorly preserved Cambrian genus *Hamptonia* Walcott somewhat resembles the interior portion of the present genus, but it may be merely the root tuft of a sponge. The presence of styles in *Hamptonia*, cited by De Laubenfels (1955, p. E39), does not seem to be borne out by either Walcott's description or his illustrations. *Choia* Walcott has a structure similar to that of *Hamptonia*, but the spicules are stouter and the body possesses a denser central region from which a fringe of longer and more widely spaced spicules project. The relation of these Cambrian genera to the Teganiidae is dubious.

GENOTYPE: *Polylophidium discus*, new species. This is the sole species.

OCCURRENCE: Leonardian; west Texas.

Polylophidium discus Finks, new species

Plate 36, figures 14–18

DIAGNOSIS: Small sponge; spicules of body wall very small but of several sizes; tufts closely and evenly spaced over whole surface; parietal gaps very small and closely spaced.

DESCRIPTION: As preserved, the individuals are circular discoidal bodies (or portions thereof), 30–40 mm. in diameter and only 2–3 mm. thick. They were probably flattened post mortem from an original globular shape. Each consists of an outer layer, 0.5–1.0 mm. thick, composed of hexacts parallel to the surface, with a superficial layer of pentacts and stauracts. These spicules are all small, 0.14–

4.0 mm. in maximum diameter, and their smooth, slender rays are rarely more than 0.07 mm. thick.

The interior of the sponge is occupied by bundles of long, very thin monaxons that radiate from the center and pass through the outer layer to project above it as separate tufts as much as 3 mm. long. The bundles, which are now flattened, are 0.2–0.7 mm. in diameter and are fairly evenly distributed over the surface, 2–4 mm. apart. The individual monaxons composing them run the complete length of the bundle and are 0.01–0.04 mm. in diameter; their outer ends are flat rather than pointed, possibly owing to breakage. What is probably a root tuft is represented on the holotype by a nearly continuous circle of longer tufts; the circle is 15 mm. in diameter, and the tufts are 5 or 6 mm. long.

No osculum is preserved on any of the specimens. Small circular pores in the body wall, 1 mm. or less in diameter and about the same distance apart, probably represent parietal gaps.

DISCUSSION: Though the specimens are incomplete, the numerous characters available for observation are quite consistent. Probably the living sponge was globular and hollow, with an osculum at the upper pole, and was rooted in the soft lime mud at the opposite end. The most complete specimen (A.M.N.H. No. 28076) is lodged in a brachiopod valve with its root tuft outermost. It was impossible to remove the delicate specimen in order to search for the osculum, as it is solidly fused to the inner surface of the valve by a deposit of silica.

The small size of these sponges suggests that they may be juveniles. However, no larger sponge with similar characters has been found in the collections. The specimen described below as "Lyssacine, species 3" may be related, but it lacks any trace of the tufts of monaxons.

MATERIAL: Ten silicified specimens, of which all but one are fragmentary. They were prepared with hydrochloric acid.

OCCURRENCE: *Horizon:* Leonardian (Word formation, limestone number 1). *Locality:* Glass Mountains, A.M.N.H. 503. *Biotope:* Mixed basin and patch-reef facies. *Lithotope:* Dark, bituminous, spiculiferous and shell-bearing, platy limestone.

TYPES: Holotype, A.M.N.H. No. 28076; paratypes, A.M.N.H. Nos. 28076:1–28076:9.

PROTOSPONGIOIDEA, *INCERTAE SEDIS*

LYSSACINE, SPECIES 1

Plate 33, figure 10; plate 36, figures 1–7

DESCRIPTION: This appears to be a fragment of a large, thick-walled sponge, which preserves somewhat more than half of the cross section, and an unknown part of the height, of the original sponge. The diameter of the original sponge must have been close to 30 mm. and its height at least as much. Its wall was at least 7 mm. thick in places, inasmuch as this thickness of the present material shows a coherent, organized arrangement of spicules. Interior to this outer rind, the arrangement of spicules becomes confused, and some of them may be foreign to the sponge; consequently it is not possible to say anything about the shape or even the presence of a cloaca. The body wall is built chiefly of smooth, slender-rayed hexacts arranged in layers parallel to the outer surface and oriented so as to form a loosely organized and discontinuous cubic mesh. Those at the surface lack the distal ray entirely, and their proximal rays are twice as long as the dermal rays. There is a distinct tendency, in both interior and surface spicules, for one of the axes in the dermal plane to be slightly longer than the other; this direction may have been parallel to the longitudinal axis of the sponge. Most of these spicules range in width from 0.55 mm. to 3 mm., the smaller ones being more numerous. In addition to the hexacts the body wall contains a large number of closely spaced, long, thin oxeas perpendicular to the surface. Individual oxeas are 0.016 mm. thick but are commonly grouped into bundles 0.2–0.5 mm. thick, which are often somewhat sinuous and may project slightly beyond the outermost layer of surface pentacts.

A third type of spicule forms a distinct dermal layer over much of the surface. These are anchor-shaped anadiaenes (see pl. 36, figs. 2–7), oriented with the cladome outermost. The orientation of the cladome axes is random, though local groups tend to be parallel. The outer profile of the cladome is a smooth parabolic curve the convexity of which, and therefore the angle at which the clads are reflexed, vary considerably from spicule to spicule. The clads are laterally compressed and expand vertically at their juncture with the long, gently tapering rhabdome. The clads are not to be considered as modified primary rays, as no axial canal is present in them, though one is present in the rhabdome. The cladomes are 0.3–0.4 mm. across, and the rhabdomes 0.4–1.4 mm. long. The anadiaenes often occur in clusters, with the longer spicules in the center projecting farther above the surface and the cladomes of all parallel. In the insoluble residues from essentially this locality (U.S.N.M. 703c) there are isolated anadiaenes of the same shape, but many of them are much larger than any found on the present specimen. Two are illustrated at the left of plate 33, figure 10. The cladome of the larger is 3 mm. wide and its rhabdome 3.1 mm. long. They probably belong to the present species but possibly come from a larger individual. (The two spicules at the right of the same figure are probably not related and are described as "furculas" under Lyssacina, *incertae sedis.*)

The surface of the sponge bears numerous circular pores, probably to be interpreted as parietal gaps, which are 0.4–0.8 mm. in diameter and are spaced rather irregularly about 1–2 mm. apart.

Biological Observations: The relationship of the anadiaenes to the anatomical organization of the present sponge is not clear. Their abundance over much of the surface of this fragment suggests that they constitute a special dermal spiculation. However, similar spicules with very much longer rhabdomes are the main root-tuft spicules in many living lyssacines, especially of the family Pheronematidae. Conceivably the area covered by the anadiaenes on the present fragment represents the site of an incipient root tuft. Such a conclusion may be strengthened by the fact that identical anadiaenes were found in a large root-tuft-like bundle of parallel spicules, including both anadiaenes and long, smooth monaxons, which was found at this same locality (U.S.N.M. 703c). It was adherent to a fragment of *Carphites plectus*, new species, but apparently had no organic connection with it. Many of the dictyosponge genera described by Hall and Clarke (1899) from the calcareous shales of the Keokuk group at Crawfordsville, Indiana, have similar, though not identical, anadiaenes. They occur, at least in some species, such as *Physospongia dawsoni*, as parts of stout bundles of monaxons which extend longitudinally along the cloacal surface and may have been prolonged basally as root tufts (Hall and Clarke, 1899, pp. 190–191, figs. 38–40). The anadiaenes themselves were not the main root-tuft spicules, for their rhabdomes are very short, as in the present species, and they are distributed throughout the length of the bundles as comitalia.

Adherent to the surface of this fragment, and possibly embedded in it during the lifetime of the sponge, are several types of large spicules, which are very probably foreign and derived from the bottom sediment. Loose spicules of the same types form a considerable proportion of the rock at this locality. Figure 2 of plate 36 shows several long, smooth oxeas, a *Carphites* type of triact, as well as a large *Docoderma* type of pentact like the isolated one illustrated on plate 46, figure 4, which is from the same locality. On figures 3 and 4 of plate 36 there is a very stout spinose oxea like the isolated ones shown on plate 46, figure 2, which are also from essentially the same locality (U.S.N.M. 703c).

Discussion: Except for the surface anadiaenes, this fragment shows many similarities to the fragments described below as "Lyssacine, species 2," which were found at essentially the same locality (U.S.N.M. 703c). The similarities include: (1) the thickness of the body wall, (2) the shape and size of the hexacts and pentacts, including their tendency to be elongated along one of the axes in the plane parallel to the surface, (3) the form and arrangement of the oxeas in the body wall, and (4) the size and distribution of the parietal gaps (somewhat smaller, however, in "Lyssacine, species 1"). Possibly, therefore, they may be conspecific, and the anadiaenes may represent a development on a local area of the sponge, perhaps associated with a root tuft. If the complete but poorly preserved small specimens, also from U.S.N.M. 703c, described further below as "Lyssacine, species 2?," represent juveniles of the same species, then we might adduce further the shape of the whole sponge to the combined description. Obviously such a synonymy must await the discovery of a well-preserved entire individual.

Regarding the broader relationships of the present specimen, the simple form of the spicules suggests inclusion with the Protospongioidea. The presence of similar anadiaenes in the dictyosponges perhaps favors such an assignment, though far-reaching conclusions on the basis of such a widely occurring type of spicule seem unwarranted.

MATERIAL: One silicified fragment, prepared with acid, A.M.N.H. No. 28074. During study, pieces of the original specimen were separated from it.

OCCURRENCE: A.M.N.H. 503, which equals U.S.N.M. 703c but is a different lens, Word limestone number 1. Loose anadiaenes are known from U.S.N.M. 703c, U.S.G.S. 2969 green (Guadalupian), and U.S.G.S. 6660 blue (Leonardian).

LYSSACINE, SPECIES 2

Plate 36, figures 8–11

DESCRIPTION: Two fragments of a large thick-walled, vasiform sponge from U.S.N.M 703c appear to be conspecific and are distinct from any other species in the collection. Possibly they are pieces of the same individual, but they cannot be fitted together. The larger fragment (pl. 36, figs. 10, 11) seems to include a portion of the oscular rim. If one may judge from its shape and dimensions, the whole sponge may have been a wide-mouthed cup with slightly bulging sides, standing more than 60 mm. high and possibly very nearly as wide. The body wall is mostly close to 10 mm. thick but thins sharply near the oscular rim. The smaller fragment has a thinner wall, closer to 5 mm. On both specimens the wall is pierced by closely and somewhat irregularly spaced, circular, parietal gaps, ranging in diameter from 0.4 mm. to 2.5 mm., which pass straight through the wall from outer to cloacal surface. There may be some anastomosing connections between them within the wall. The skeleton is composed of two kinds of spicules: simple, slender-rayed hexacts and slender oxeas. The hexacts have one axis longer than the other two, and most often one ray longer than the other five; they are oriented randomly with respect to one another, but the long axis is usually parallel to the surface. The length along this axis varies from 1.5 mm. to 4.0 mm., and the longest ray is rarely more than twice the length of the short rays. The oxeas are closely spaced throughout the body wall and are uniformly oriented perpendicular to the surface; individual oxeas are mostly nearly as long as the wall is thick, though some are distinctly shorter. Identical oxeas line the cloacal surface just inside the oscular margin, oriented perpendicular to the rim of the osculum. No dermal or cloacal specializations are present, except for reduction or loss of the outer rays of the hexacts.

DISCUSSION: The simple spiculation and lack of dermal specialization suggest inclusion of this form among the Protospongioidea. The random orientation of the hexacts, the presence of parietal gaps, and the strong development of monaxons perpendicular to the surface further suggest a relationship to the Teganiidae. The presumably vasiform shape, however, is untypical of that family. At the same locality as the present specimens are some smaller, poorly preserved, but more complete sponges which show certain resemblances; they are described below as "Lyssacine, species 2?." They have a subprismatic shape reminiscent of some of the dictyospongids. Whether they or the present specimens are indeed related to the dictyosponges cannot be determined from this material. If this form is truly a protospongioid, it should be noted that it partakes of the general late Paleozoic trend in that group towards increasing thickness of the body wall. The fragment described above as "Lyssacine, species 1" may be conspecific with the present specimens, as there discussed.

MATERIAL: Two silicified fragments prepared with acid, A.M.N.H. Nos. 28075, 28075:1.

LOCALITY: U.S.N.M. 703c, Word limestone number 1, Glass Mountains.

LYSSACINE, SPECIES 2?

Plate 35, figures 2–5

DESCRIPTION: The specimen illustrated on plate 35, figures 2–5, is the only whole one, but most of the others clearly represent portions of similar specimens. Their general form is maintained by a coarsely granular siliceous replacement in which are embedded such spicules as are preserved. The shape is prismatic, possibly with eight sides, the base is rounded or bluntly pointed, and the sides are straight and parallel. The illustrated specimen is 35 mm. high and the width, probably distorted by compaction, is 8 mm. by 17 mm. The body wall is 2.0 mm. thick; on the other fragmental specimens, some of which may have been larger individuals, the wall thickness ranges from 2.0 mm. to 6.0 mm. Numerous circular to elliptical pores, or parietal gaps, pierce this body wall over most of its surface; they measure 0.3–2.0 mm. in diameter and are spaced somewhat irregularly 1–3 mm. apart. They can be seen to anastomose within the wall on many of the fragments. The few spicules preserved on the exterior surfaces, as well as the more numerous ones on the cloacal surfaces, are smooth, slender-rayed pentacts, which are not always in parallel orientation. On the cloacal surface of the illustrated specimen, just below the oscular rim, are several straight oxeas parallel to the long axis of the sponge. On a fragmental specimen, similar oxeas are oriented perpendicular to the cloacal and outer surfaces, running completely through the body wall. Within the body wall of many specimens there are simple hexacts of the same proportions as the surface pentacts. All these spicules are of roughly the same size: 0.5–2.0 mm. from tip to tip and about 0.1–0.2 mm. in ray thickness. There is no indication of a root tuft.

DISCUSSION: The poor preservation of these specimens makes it difficult to determine their affinities, but they are closest in skeletal construction to "Lyssacine, species 2." Similarities include: (1) the general vasiform shape, (2) the thick wall pierced by numerous anastomosing canals, (3) the form, size, and distribution of the pentacts and hexacts, (4) the presence of monaxons in the body wall perpendicular to the surface, and (5) monaxons on the cloacal surface perpendicular to the oscular rim. Unfortunately only a few spicules are present on each of the specimens, and none of the specimens shows all five of the enumerated characters. The first two characters are also shared by *Endoplegma calathus* of the same locality, which furthermore has a similar subprismatic shape. The last three characters, however, are shared only with "Lyssacine, species 2," and of the known forms in the collection it is certainly the closest.

MATERIAL: One complete specimen, five large fragments, and a dozen or more small fragments, all silicified and prepared with acid; U.S.N.M. No. 127652.

OCCURRENCE: *Horizon:* Word limestone number 1. *Locality:* U.S.N.M. 703c. *Biotope:* Mixed basin and patch-reef facies. *Lithotope:* Dark, platy, bituminous, spiculiferous limestone.

BRACHIOSPONGIOIDEA FINKS,
NEW SUPERFAMILY

DIAGNOSIS: Vasiform sponges with large, circular, parietal gaps; specialized dermal layer of large spicules, usually pentacts, with characteristic processes on distal surface and in some species with extra tangential rays; a supradermal quadrate mesh of small pentacts or stauracts often present; interior spicules without uniform orientation.

DISCUSSION: In the west Texas Permian a large number of lyssacine species bear highly specialized dermal spicules which are often unusually large and have various outgrowths on their distal surfaces, as well as supernumerary tangential rays. In many species these specialized spicules are covered externally by a fine quadrate mesh of smaller and simpler spicules. In adult individuals the dermal spiculation, including the fine outer mesh when present, tends to fuse into a more or less rigid structure. This complex of characters sets these forms apart from the more simply organized members of the protospongioid stock, in which dermal specialization is poorly developed. Isolated spicules resembling the large dermalia have been reported by various authors from Carboniferous and earlier strata in many parts of the world, a fact that suggests that the Permian species may be the descendants of a distinctive stock of Paleozoic lyssacines. No complete sponges are available to us, however, until we go as far back as the Ordovician, where the well-known *Brachiospongia* Marsh, 1867, presents a set of characters agreeing with those enumerated above, excepting only a lack of supernumerary rays on the large dermalia. Although the possibility exists that these characters have arisen independently in several lines of descent, the writer prefers to note their similarity and possible common ancestry by establishing the superfamily Brachiospongioidea for the reception of these forms.

Beecher established the family Brachiospongiidae for the Ordovician genera *Brachiospongia* Marsh and *Strobilospongia* Beecher, giving the following diagnosis (Beecher, 1889, p. 13): "Dermalia forming a quadrate mesh, in which are immersed large free pentacts, or modified hexacts. Parenchyma thick, with large free hexacts, and more or less cylindrical canals, the outer ends of which are covered with the dermal mesh."

This set of characters would cover most of the species assigned to the superfamily Brachiospongioidea in the present paper. Beecher did not make a family character of the presence of nodes on the distal surface of the large dermalia, which he describes in *Brachiospongia*, but did so with the large size of the spicules and with the presence of an outer quadrate mesh. The thickness of the body wall and the presence of parietal gaps, or canals, which Beecher does include, are also essential features of the superfamily as here understood. The thickness of the wall sets these sponges apart from the superfamily Protospongioidea, and the parietal gaps, while present in some protospongioid families, are absent in the large family Dictyospongiidae of that complex.

Another feature that seems to be characteristic of the Brachiospongioidea is the tendency for the interior spicules and large dermalia, though not the outer quadrate mesh, to lack a parallel arrangement. This feature may have some phylogenetic significance, for the skeletal net in the great group of post-Paleozoic dictyonine hexactinellids is almost universally organized as a parallel cubic mesh. It is likely that many if not all of the dictyonines arose from that line of the protospongioids in which the primitive parallel orientation of spicules was maintained, namely, the Protospongiidae and their descendants, the Dictyospongiidae. The Brachiospongioidea would then represent a line that very early tended to lose this parallel orientation.

Within the Brachiospongioidea several subdivisions can be recognized, one of which is represented by *Brachiospongia* itself, together with such relatives as it may have. De Laubenfels (1955, p. E76) revised Beecher's diagnosis of the Brachiospongiidae and characterized the family by the thick wall and by the radially lobate form of the sponge. As indicated above, the thickness of the wall is characteristic of the whole superfamily, but the lobate external form may well be a significant family feature. *Brachiospongia* itself lacks a root tuft, and this feature may prove to be equally diagnostic. *Colpospongia* Lamont, 1935, and *Rhaeaspongia* Lamont, 1935, share both these characters; De Laubenfels places the latter in synonymy with *Brachiospongia*, and possibly the former should be treated likewise. The large dermal pentacts of *Brachiospongia* bear a round knob in place of the distal ray, as well as a single knob on the distal surface of each of the tangential rays close to the crossing; they are of the same form as the dermalia in *Dococerma* sp. from Mexico, described below. *Strobilospongia* Beecher, 1889 (as De Laubenfels indicates, this is probably a junior synonym of *Pattersonia* Miller, 1882), was included in the family as originally established, but the characters of its dermal spicules have never been completely observed, and it differs from *Brachiospongia* in that it has a well-developed root tuft, and its radial lobes are solid rather than hollow. This genus may be quite unrelated to *Brachiospongia*. The same may be said of *Oncosella* Rauff, 1894, which De Laubenfels also assigns to this family; it has a root tuft, and the dermal spicules do not show the specializations characteristic of the superfamily.

Another distinctive group of genera is that assigned to the new family Dococermatidae. This group retains the outer quadrate mesh, but the large dermalia increase in size, generally have more than the single distal protuberance seen on each tangential ray in *Brachiospongia*, develop supernumerary tangential rays, and often show a pronounced reflection of these rays towards the interior. In the Permian species, in which the interior spicules are preserved, another peculiar feature can be observed, namely, that they are almost entirely diacts and triacts, the latter apparently formed by the reduction of a hexact to three of its rays in one plane. *Dococerma* and the closely related *Carphites* form the core of this group. The associated *Acanthocoryna* may not belong here for reasons discussed under that genus. Besides these Permian forms there are earlier ones, represented only by dermal spicules, which may be related. One is the poorly known *Astroconia* Sollas, 1881, from the Silurian of England and Canada. This shows no reflection of rays but does bear highly developed distal protuberances, including short supernumerary tangential rays distal to the principal ones; both features are characteristic of *Docoderma*.

A more complex case is represented by the genera *Tholiasterella* and *Asteractinella* from the lower Carboniferous of Scotland, established by Hinde (1888a) and based on isolated spicules as well as on small coherent fragments of the dermal layer in the case of the former. The spicules of *Tholiasterella*, presumably dermalia, consist of a large proximal ray with five to nine tangential rays, which are sometimes reflexed and the distal surfaces of which frequently bear numerous tubercles or blunt vertical spines as well as short lateral branches. In the coherent fragments of the dermal layer the spicules are intimately interlocked and fused where in contact. *Asteractinella* was established for isolated spicules in which numerous rays diverge from the center in various directions. In some spicules one ray is longer than the others and may represent the proximal ray; in others the rays are subequal in length, and the spicule has the form of an oxyaster; and in still others a number of rays diverge in one plane, probably that of the sponge surface, while three or four large rays diverge obliquely beneath this plane. In the last type the presumptive outer surface may be tuberculate. Spicules of *Tholiasterella* are illustrated in plate 40, figures 4–7, which are copied from Hinde, 1888a. Their similarity to those of *Docoderma rigida*, illustrated on the same plate, is apparent. Subsequently, Vandercammen (1950) described several nearly complete specimens of a plicate, vasiform sponge, from the Tournaisian of Belgium, which contained essentially all the spicule types assigned by Hinde and later workers to the various species of *Tholiasterella* and *Asteractinella*. Vandercammen concluded that the two genera, as well as their several species, were synonymous, and he made *Tholiasterella* a junior synonym of *Asteractinella*. If it be assumed that the specimens described by Hinde as *Tholiasterella* are indeed conspecific with the Belgian sponges of Vandercammen, the presence of spicules of oxyaster type in the same specimen casts strong doubt on the relationship of this species to *Docoderma* or to the Brachiospongioidea in general, for this combination of spicule types occurs in the genus *Wewokella* Girty, 1911, which is common in the Pennsylvanian and upper Mississippian of the United States and is probably a calcareous sponge allied to *Astraeospongia* Roemer. Inasmuch as its spicules, like those of Vandercammen's specimens, are stouter and blunter-rayed than most of those described by Hinde as *Tholiasterella*, the possibility remains that *Tholiasterella* is not in fact related to *Asteractinella* and may be a docodermatid after all. Until the Scottish type material of Hinde can be examined further, the matter must necessarily rest here. It may be noted in passing that the spicules assigned by Weller (1930) and Bailey (1935) to *Asteractinella* and *Tholiasterella*, from the Pennsylvanian of the United States, most probably belong to *Wewokella*.

Carter, in 1879, established the genus *Holasterella* for some lower Carboniferous lyssacine material from the British Isles. The type species was based on a single, poorly preserved, complete individual, and two other species were created for isolated spicules. Hinde (1888a), in reviewing these species, established a new genus for each of the latter two, namely, *Spiractinella* and *Acanthactinella*. The spicules of all three genera appear to be hexacts in which branching of the primary rays is common, or in which extra rays are given off from the crossing at various angles. The relative stoutness and elaborate branching shown by these spicules suggest that they belong to the present superfamily, but their more precise relationships cannot be determined. Some of the polyact spicules attributed to *Holasterella* by Hinde (1888a, pl. 8, figs. 2e–g) may actually belong to *Tholiasterella* as suggested by Vandercammen (1950, p. 7).

Another subgroup of the Brachiospongioidea is represented by the new Carboniferous and Permian genus *Stioderma*, together with at least some of the Carboniferous spicules described as *Hyalostelia* Zittel, 1879, by that author and later workers. In these forms the dermal hexacts are not strongly enlarged, but the distal ray is represented by a large spherical or club-shaped knob, with similar swellings developed on the tangential rays. In adult specimens of *Stioderma*, a rigid but non-quadrate outer mesh may be formed by fusion of small dermalia with the distal rays of the large dermalia; this mesh does not cover the parietal gaps. Except for the absence of a quadrate supradermal mesh that covers the parietal gaps, and for the fact that the dermalia are not significantly larger than the interior spicules, the members of this group possess the diagnostic characters of the superfamily to an eminent degree.

Appended to the Brachiospongioidea with considerable doubt is a highly specialized species from the west Texas Permian, described by Girty (1909) as *Stromatidium typicale*. Whatever its broader relationships may be, the peculiar nature of this sponge would seem to warrant the establishment of a separate family for it. It is constructed of separate, superposed layers of highly spinose pentacts the tangential rays of which bifurcate repeatedly and fuse with those of the adjacent spicules in the same layer. Each layer, with its rigid net formed by the branching of the distally spinose tangential rays, is like the dermal layer of one of the more highly specialized brachiospongioids, and it is for this reason that the species is tentatively placed here. Otherwise its characters are entirely different from those of the other members of the superfamily. It may be a very specialized offshoot of this stock, but its relation to the other members of the group must certainly be remote.

In summary, it is not difficult to imagine how an early Paleozoic form similar to *Brachiospongia* (but lacking its specilized lobate form and possessing a root tuft) could have given rise, on the one hand, to the docodermatids by an increasing enlargement and elaboration of the dermal spicules, as well as loss of rays on the internal spicules, and, on the other hand, to the stiodermatids by loss of the supradermal layer and enlargement of the original five distal nodes of the dermalia. In both of these lines there is a parallel trend towards hypertrophy of the dermal layer and its fusion into a rigid supporting framework.

From the Jurassic of Germany, Schrammen (1936) has reported very large isolated hexacts, similar to those seen in *Carphites* of the present collections. Schrammen states that they do not appear to belong to any of the known Jurassic species, nor are they like any known from more recent lyssacines. It may be that these are from brachiospongioid species, and the stock may have thus persisted well into the Mesozoic era.

INCLUDED FAMILIES: Brachiospongiidae, Beecher, 1889 (Ordovician, Silurian?); Docodermatidae, new family (Silurian?, Carboniferous, Permian); Stiodermatidae, new family (Carboniferous, Permian); ?Stromatidiidae, new family (Permian); ?large lyssacine spicules (Jurassic).

DOCODERMATIDAE FINKS, NEW FAMILY

DIAGNOSIS: Dermalia very stout, often with distal excrescences and extra tangential rays; interior spicules triacts and diacts oriented parallel to the surface.

DISCUSSION: The genera of this family are separated chiefly on the form of the dermalia. They are all large vasiform sponges with well-developed parietal gaps. Probably all of them possess a stout root tuft. The body wall has a layered structure, with distinctive types of spicules in each layer. In the most highly developed forms four such layers can be recognized; starting from the outer surface they are: (1) a supradermal layer of small spicules covering the whole surface, the parietal gaps included, in the form of a fine quadrate mesh; (2) a dermal layer of very large pentacts or hexacts, sometimes of more than one form, which bear various types of outgrowths on their distal surfaces and frequently have additional tangential rays; (3) an interior spiculation largely of triacts or diacts organized into crisscrossing bundles parallel to the surface; and (4) a gastral layer of spicules similar to those of the dermal layer. Individual genera show various modifications of this typical scheme. The supradermal layer is absent in *Acanthocoryna*, is formed of pentacts or stauracts in *Docoderma*, and is formed of triacts in *Carphites*. The gastral layer is absent in *Carphites*, and the interior spiculation of that genus is divided into two zones, an outer containing only small spicules and an inner containing both small and large. In adult specimens of *Docoderma* the two outermost layers, that is, the supradermal and dermal layers, undergo a more or less complete fusion so as to form a continuous rigid framework. In that genus also, hexacts occur among the triacts and diacts of the interior spiculation; these may perhaps be considered as belonging to the dermal and gastral layers, for those nearest the dermal layer begin to develop the extra rays characteristic of the dermalia.

The diagnostic features of this family are the great stoutness and elaboration of the dermal and gastral spicules, together with the virtual restriction of the interior spiculation to diactinal monaxons and triacts organized into bundles parallel to the surface. The last-named type of spicule is indeed a most peculiar form, and, were it not absent from *Acanthocoryna stauroma*, which may well not belong here, it would be characteristic of all species in the family. As were all hexactinellid spicules with fewer than six rays, it was probably derived from the basic hexact form by suppression of rays. In this case, the three rays are in the same plane, representing one complete axis of the original hexact together with half of another axis. The rays are perfectly smooth and taper to a sharp point. In some the rays are straight, and the side ray leaves the main axis at a right angle. In many, however, the side ray is at an acute angle to the main axis. Furthermore, any or all of the rays may be gently curved, and, if the main axis is curved, the side ray may be on either the convex or the concave side. (See pl. 46, fig. 3.)

The broader taxonomic significance of such triact spicules is difficult to estimate. Inasmuch as they represent a simple reduction of the basic hexact form, one might expect them to arise easily in many unrelated species. They appear, however, to be relatively uncommon. Among Recent lyssacines, similar, but not identical, triacts are present in the hexasterophoran genera *Holascus*, *Taegeria*, and *Euplectella* as well as in the amphidiscophoran *Hyalonema*. The former group may be related to the brachiospongioids, as is discussed below under the superfamily Euplectelloidea. Among Paleozoic sponges, the docodermatids are, so far, the only ones in which triacts can be demonstrated unequivocally. One possible example of such a spicule was illustrated by Hall and Clarke (1899, p. 65, fig. 11) in connection with the poorly known Devonian species *Dictyospongia? marcellia* Clarke, 1894, but it was not mentioned in the text. The Cambrian genus *Vauxia* Walcott, 1920, may contain similar triacts, but its poorly preserved spiculation is difficult to interpret; neither Walcott's illustrations, nor the type specimens themselves, which the writer has examined, present the form shown in the highly idealized diagram of De Laubenfels (1955, p. E77, fig. 4). Thin sections of the Permian *Stereodictyum orthoplectum*, new species, seem to show similar triacts, but an additional ray, or rays, not in the plane of the section, may well be present.

Another feature of the family is the presence of comitalia, that is, of small spicules which accompany the larger interior and root-tuft spicules, more or less coating their surfaces. In both *Docoderma* and *Carphites* they include small curved oxeas and strongyles (some of the latter very fat and nearly bean-shaped) as well as triacts. Very small, simple hexacts may also function in this capacity. One specimen of *Carphites diabloensis* has yielded an umbel and an anadiaene, which, if truly belonging to the sponge, may have served as comitalia. In *Acanthocoryna* only small curved oxeas have been observed, and their function as comitalia has not been demonstrated.

The similarity of the body plan and dermalia of the docodermatids to those of *Brachiospongia* is discussed above under the superfamily. It might be pointed out here that the arrangement of the interior spicules in bundles parallel to the surface is not characteristic of the other brachiospongioids, so far as they are known, but is a significant feature of the family Dictyospongiidae. A further, but probably less significant, similarity between the Docodermatidae and the Dictyospongiidae is the presence of clemes in the root tufts of *Docoderma rigida* and of several dictyosponge species. Also, the comitalia of small curved oxeas and strongyles are known from several Mississippian dictyosponge genera at Crawfordsville, Indiana (see Hall and Clarke, 1899, pp. 30–33, 166–197). The umbel and anadiaene associated with one specimen of *Carphites diabloensis*, if truly belonging to this sponge, would be an additional point of similarity to the same dictyosponges. Considering the total picture, however, the writer prefers to lay stress on the features characteristic of the superfamily Brachiospongioidea that differentiate the members of this family from the dictyosponges. An alternative hypothesis would, of course, be to derive the dócodermatids directly from Mississippian dictyosponges through forms similar to *Endoplegma calathus*. In this case the Silurian *Astroconia*, as well as the other brachiospongioid families, would represent lines independent of the late Paleozoic docodermatids.

The question of the relationship of *Astroconia*, *Tholiasterella*, and *Asteractinella* to the present family is discussed above under the superfamily.

INCLUDED GENERA: ? *Astroconia* Sollas, 1881 (Silurian; England, Canada); ? *Tholiasterella* Hinde, 1888a (Carboniferous; Europe, North America); *Docoderma*, new genus (Pennsylvanian, Permian; North America); *Carphites*, new genus (Permian; North America); ? *Acanthocoryna*, new genus (Permian; North America).

DOCODERMA FINKS, NEW GENUS

DIAGNOSIS: Dermalia pentacts or stauracts with strongly reflexed tangential rays bearing papillae or other processes on distal surfaces; gastralia similar to dermalia; supradermal layer of small pentacts or stauracts; interior spicules including triacts, oxeas, and strongyles.

DISCUSSION: The species of this genus are separated chiefly on the form and ornamentation of the dermalia. The distinctive characters common to all species of *Docoderma* are: the tuberculate outer surface of the dermalia, the strong reflection of their primary tangential rays, the presence of extra tangential rays on at least some dermalia, the absence of a distal ray on all dermalia, the construction of the supradermal mesh out of pentacts or stauracts, the presence of gastral spicules similar to the dermalia, the presence of both triacts and oxeas in the interior spiculation, and the presence of small, curved strongyles and oxeas which accompany the larger spicules of the interior and root tuft as comitalia. To these might be added the following characters which, because of poor preservation, have not been observed in all species, but which may well be characteristic of the genus: the presence of simple hexacts in the interior spiculation, and the presence of clemes in the root tuft.

The clemes in the root tuft of *Docoderma rigida* are of interest, because they are very similar to ones that occur in the dictyospongid genera *Physospongia*, *Lyrodictya*, and *Acloeodictya* from the Mississippian beds at Crawfordsville, Indiana, described by Hall and Clarke (1899). Unlike the clemate root-tuft spicules of the living *Euplectella*, in which the cylindrical shaft of the spicule is perfectly straight, these clemes have a zig-zag form, with the main shaft bending slightly towards each of the alternately placed projections on opposite sides of the spicule. The clemes of *Docoderma* differ from those of the dictyosponges in that the projections make a more acute angle with the main shaft, and the outer border of the projection is a straight line continuous with the outline of the shaft itself, rather than showing a distinct outward curvature. (See pl. 33, fig. 5, and pl. 40, fig. 10, of the present paper as well as Hall and Clarke, 1899, p. 31, fig. 5, and elsewhere.) The clemes of the dictyosponges accompany smooth monaxons, as in the present genus, grouped into bundles which were found only on the interior of the body wall but which were probably continuous with the root tuft. They are accompanied in the dictyosponges also by small diaenes, as comitalia, similar to those seen in "Lyssacine, species 1" of the present paper, but not in *Docoderma*. It is interesting to note that small, curved strongyles and oxeas have been isolated from these same dictyosponge genera, as well as from others in the same beds, which resemble the comitalia of *Docoderma*. For reasons stated above, under discussion of the superfamily, the writer does not consider the docodermatids and the dictyosponges to be closely related, despite such similarities.

The species assigned here to *Docoderma* are certainly closely related to those assigned to *Carphites*. The two genera can be separated absolutely, so far as they are now known, by the lack of gastral spicules in the species of *Carphites* and by the construction of the supradermal mesh in that genus from triacts rather than pentacts or stauracts. The most readily observable differences are in the dermalia, which lack, in *Carphites*, distal outgrowths, reflexed rays, or extra rays. A few spicules, however, of *C. plectus* show rudiments of such features, testifying to its relationship to *Docoderma*. As discussed under *Carphites*, below, it is possible to arrange the several species of the two genera in order of decreasing complexity of the dermal spicules.

GENOTYPE: *Docoderma rigida* Finks, new species.

INCLUDED SPECIES: *Docoderma rigida*, new species, *D. papillosum*, new species, *Docoderma* sp.

OCCURRENCE: Middle Pennsylvanian (Magdalena formation), Leonardian, Guadalupian; west Texas, New Mexico, western Sonora (Mexico).

Docoderma rigida Finks, new species

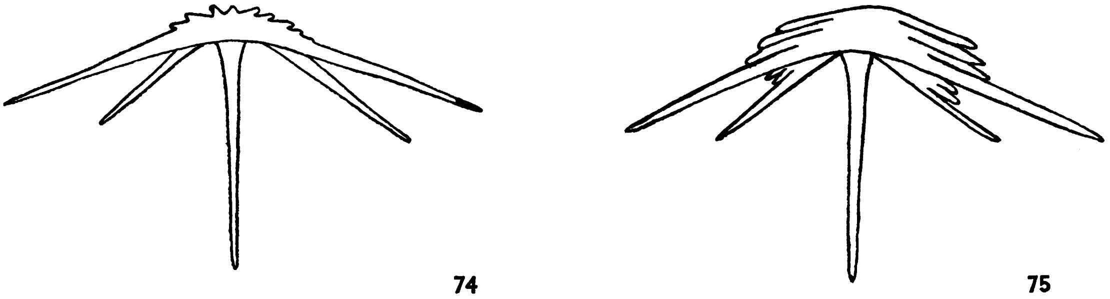
Plate 33, figure 5; plate 39, figures 1–6; plate 40, figures 1–3, 8–11; plate 41, figures 1, 2; text figures 74–76

DIAGNOSIS: Tangential rays of dermalia long, smooth, and strongly reflexed; numerous extra tangential rays radiating from the distal surface of the crossing, and in the adult spicule becoming grouped into eight to 12 beam-like structures, ornamented with papillae, which radiate in the dermal plane and articulate or fuse with those of adjacent spicules to form a rigid dermal layer.

DESCRIPTION: This is a very large, thin-walled, broadly vase-shaped sponge with a stout root tuft. The dermal pentacts or stauracts have very long, smooth, strongly reflexed, tangential rays. Shorter supernumerary rays radiate from the distal side of the crossing. They are numerous in the juveniles, but in adults fuse to form eight to 12 beam-like rays, parallel to the surface, which may branch distally and commonly terminate in tooth-like processes. The beams interlock or fuse with those of adjacent spicules to form a rigid net with triangular interspaces. The outer surfaces of the beam-like rays bear hemispherical papillae. In some areas they develop arborescent processes which fuse with an overlying supradermal layer of small stauracts or pentacts which form a continuous, very fine, and uniform quadrate mesh. The gastral surface is unknown in this species, but probably consists of less elaborate pentacts or stauracts. The interior spicules are not united and are in random orientation. They consist of hexacts of several sizes (those nearest the dermal layer being heavier and in some specimens possessing extra rays and distal processes), the characteristic docodermatid triacts, and oxeas. The root tuft is composed of parallel, long, smooth monaxons of several thicknesses, together with clemes. Very small curved oxeas and strongyles coat the larger spicules of both body wall and root tuft. The root-tuft spicules extend well up into the body of the sponge. Large circular parietal gaps pierce the body wall but are partly concealed on the exterior by the rays of the large dermal spicules.

MEASUREMENTS: External form: Height of adult in excess of 220 mm., maximum diameter greater than 120 mm. and possibly greater than 240 mm., diameter of root tuft as much as 50 mm., length unknown. Adult dermalia: Width at surface 1–5 mm., with primary tangential rays up to 20 mm. or more long and up to 0.9 mm. thick; surface beams 0.3–0.5 mm. wide and 1.0–2.0 mm. deep, with papillae 0.1–0.3 mm. in diameter. Juvenile dermalia: Width 1.0–1.5 mm., tangential rays reflexed as much as 45 degrees. Supradermal layer: First-order mesh spaces 1.0 mm., second-order 0.5 mm., diameter of elements 0.1 mm. thick. Internal skeleton (adult): Hexacts 1–5 mm. wide, rays 0.05–0.5 mm. thick; triacts 0.5–5.0 mm. long; oxeas 0.2–2.0 mm. long and 0.03–0.05 mm. thick. Root tuft: Smooth monaxons 0.05–1.0 mm. in diameter and more than 200 mm. long; clemes of similar dimesnsions to larger smooth monaxons, with barbs 0.1 mm. long and inclined 30 degrees to shaft. Comitalia of both root tuft and interior skeleton: Curved oxeas 0.3–0.6 mm. long, curved strongyles 0.3 mm. long. Parietal gaps: Adults: on interior 1–3 mm. in diameter, spaced 4–5 mm. apart; juveniles: 0.1–0.5 mm. in diameter, and 0.4–1.0 mm. apart.

BIOLOGICAL OBSERVATIONS: This species is the largest lyssacine in the collection. As has *Stioderma coscinum*, new species, of similar size, it has solved the problem of supporting a large but thin-walled, cup-shaped body by developing a heavy and rigid dermal skeleton. In both species, union of the dermalia is effected by fusion of tangential rays. Complete rigidity in the juvenile sponge, however,



FIGS. 74, 75. *Docoderma rigida* Finks, new species. 74. Side view of dermal spicule of juvenile sponge, showing initial protuberances on outer surface of dermal rays. 75. Side view of dermal spicule of mature sponge, showing horizontal extension of protuberances parallel to primary dermal rays; they are fused into beam-like structures the ends of which interlock with those of adjacent spicules to form a rigid dermal layer.

would prevent expansion of the body during growth. Therefore, the dermalia of the juveniles are not fused, and the articulating rays undergo a gradual development. An ontogenetic series can be reconstructed from the specimens of the present collection, if it be assumed, as seems reasonable, that the thin-walled fragments with smaller spicules and smaller parietal gaps do, indeed, represent younger individuals. The initial stage is represented by a single distal process on each of the primary tangential rays near the crossing. Subsequently more of them develop in the vicinity of the crossing and elongate parallel to the sponge surface and exterior to the reflexed primary rays. They begin to branch and form discrete groups of subparallel processes. Within each such group the individual processes become fused to one another, except at their tips, and the fused bundle assumes the form of a laterally compressed beam. As the beam continues to elongate, the free tips of the processes interdigitate with those of adjacent spicules, thereby setting a limit to further growth. Apparently, even in this ultimate state, the spicules are not solidly fused at the points of articulation, for they are readily separable on the present specimens, and the complex post-mortem folding of the body wall is evidence of considerable flexibility. (It is to be noted that where the tip of a beam abuts against the side, rather than the tip, of another, the two spicules are rigidly fused by secondary silica.) The strong, yet flexible, skeleton thus produced may have permitted this sponge to live in somewhat agitated water. The localities from which the species is known, however, are all of the basin facies, which was most likely a rather still-water environment. The type locality (U.S.N.M. 703c) contains faunal elements of patch-reef facies, but most of the associated lyssacines are very delicate forms which probably could not have been preserved as they are if the water were agitated.

DISCUSSION: As far as the available material permits us to understand the genus, the beam-like groups of extradermal rays in this species are absolutely diagnostic. U.S.N.M. 703c is the only locality from which coherent fragments are known. Isolated dermalia are known from A.M.N.H. 369a, and from P.U. 1r. Isolated clemes, like those in the root tuft of the holotype, are known from the type locality, from A.M.N.H. 369, and from A.M.N.H. 46; it is not likely that the clemes are diagnostic of this species alone.

The precise shape of this sponge could not be determined from the available material. The holotype is the most complete specimen, but the body wall has been folded in upon itself in a complex manner, and it was deemed inadvisable to free the rather fragile skeleton entirely from the matrix. Indeed it is impossible to say whether this specimen represents one individual bent double, two individuals side by side, or two individuals partly conjoined. The figures given above for the maximum diameter of the sponge are estimates based on the present dimensions of the crushed and incomplete specimen; the larger

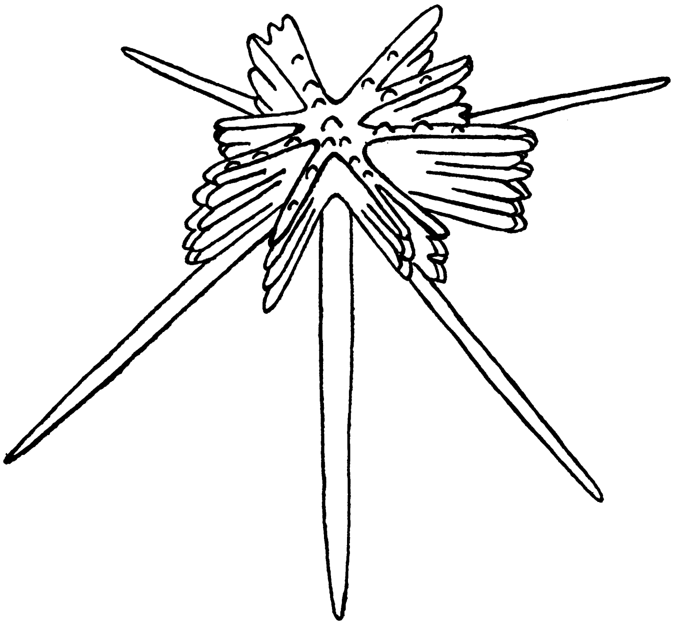


FIG. 76. *Docoderma rigida* Finks, new species. Oblique view of mature dermal spicule, showing long vertical ray and four primary dermal rays, with beam-like supernumerary rays above them; the beams branch in the dermal plane and conceal the basic rectangular symmetry of the spicule.

figure assumes that it is a single individual.

MATERIAL: From U.S.N.M. 703c: one large silicified specimen (possibly two individuals) prepared with acid, together with fragments removed from it, U.S.N.M. No. 127659; also six fragments of juveniles together with loose spicules, U.S.N.M. Nos. 127660a–127660g. From A.M.N.H. 369a: four loose dermalia, A.M.N.H. Nos. 28078:1–28078:4. From P.U. 1r, one juvenile dermal spicule.

OCCURRENCE: *Horizons:* Upper Leonardian (Word limestone number 1); Leonardian (Bone Spring limestone). *Localities:* U.S.N.M. 703c, Glass Mountains; A.M.N.H. 369a, Guadalupe Mountains; P.U. 1r, Sierra Diablo. *Biotopes:* Mixed basin and patch-reef facies; basin facies. *Lithotope:* Dark, spiculiferous, bituminous, slabby limestone.

TYPES: Holotype, U.S.N.M. No. 127659; paratypes, U.S.N.M. Nos. 127660a–127660g, from U.S.N.M. 703c.

Docoderma papillosum Finks, new species

Plate 41, figures 3–6; plate 42, figures 1–7, 9

DIAGNOSIS: Dermalia consist of (1) very stout pentacts or stauracts, with strongly reflexed, papillose, tangential rays, and (2) small, star-shaped spicules with multiple, stubby, tangential rays; dermalia not fused together.

DESCRIPTION: This is a large, cup-shaped sponge the exact form of which is not known. It probably had a stout root tuft. The dermalia are of two contrasting sizes and shapes. The larger have four strongly reflexed, very stout, tangential rays, which bear numerous, small, papillose, or arborescent processes on the outer side, especially concentrated near the crossing. A few of these spicules have a fifth tangential ray arising from the crossing or branching from one of the primary rays. Because of the reflection of the rays, the center of the spicule is markedly elevated. The smaller dermalia, disposed in the spaces between the larger, have numerous stubby tangential rays, produced by repeated branching of the four primary rays. Some of these spicules are distorted where they touch the larger dermalia. Their centers are not elevated. Both types of dermalia have a very short proximal ray, or possibly none at all, and no trace of a distal ray. The larger dermalia rarely touch one another; they tend to be in parallel orientation, but many are out of alignment and appear to have been so during the lifetime of the sponge. In the adult sponge, a fine quadrate mesh of continuously fused, small pentacts covers the whole surface and is fused to the underlying dermal spicules. The outer surface of this supradermal layer bears closely set arborescent processes. The cloacal lining, which is continuous with the dermal layer over the rim of the osculum, consists entirely of spicules like the large dermalia. The gastralia are smaller, however, and their tangential rays are only slightly reflexed, if at all. In some specimens a very short distal ray is present. The gastral spicules in the adult stage appear to be fused where in mutual contact. The interior spicules are randomly oriented parallel to the surface. They include simple hexacts, pentacts, stauracts, and oxeas of several sizes, together with smaller triacts, oxeas, and strongyles, which parallel them as comitalia. Rather irregularly distributed circular parietal gaps pierce the body wall.

MEASUREMENTS: Wall thickness: 3–15 mm. Large dermalia: Tangential rays reflexed 10 degrees to 30 degrees, 2–25 mm. long, 1–4 mm. thick. Small dermalia: 1–3 mm. across top, rays 0.3–1.0 mm. thick. Gastralia: 2–20 mm. across, rays 0.3–0.9 mm. thick, reflexed less than 10 degrees. Supradermal layer: Mesh spaces 0.5–2.0 mm. Papillae of all surface spicules: Diameter 0.1–0.3 mm., spaced 0.4–0.8 mm. apart; papillae may bear smaller papillae 0.02 mm. or less in diameter. Interior spicules: Hexacts: width 0.25–1.8 mm., rays 0.05–0.26 mm. thick; pentacts: width 0.5–1.3 mm., rays 0.05–0.1 mm. thick; stauracts: width 2.5 mm., rays 0.1 mm. thick; triacts: width 0.5 mm., rays 0.05 mm. thick; oxeas: length 0.25–6.0 mm., thickness 0.02–0.13 mm.; strongyles: length less than 0.5 mm., thickness less than 0.1 mm. (thickness relative to length is variable). Parietal gaps: Diameter 2–3 mm.

BIOLOGICAL OBSERVATIONS: The presence of two distinct types of dermalia appears to be characteristic of this species and, despite the occurrence of a few intermediate forms, it is not likely that the small polyact type is an early ontogenetic stage of the large four-rayed spicules. In the smaller sponges, here interpreted as juveniles (see pl. 42, figs. 5, 6, 7, 9), the large dermalia have shorter rays, but the ray thickness is very nearly the same as in the adults; consequently the spicule rays of the juveniles are proportionately stouter and more strongly tapering. The spicules are also more closely spaced. It might be inferred from these differences that the spicules are pulled apart as the sponge grows and their rays are added to in length but very little in thickness. However, it is also possible to interpret the smaller sponges as variant adults rather than juveniles. A third possibility, that the smaller and larger specimens represent two distinct species, seems much less likely, as they both occur at the same localities and have many characters in common.

It is worthy of note that this species is restricted to the Sierra Diablo region, where it occurs in the basin facies of the Bone Spring limestone just in front of the main reef. It has been found at several levels in this formation, from the base up to the highest beds immediately beneath the Victorio Peak formation. It has not been found in the contemporaneous, and presumably similar, basin facies of the Guadalupe Mountains or Glass Mountains.

DISCUSSION: This species can be distinguished from *D. rigida* by the absence of supernumerary rays on the dermalia distal to the reflexed primary rays. It can be distinguished from *Docoderma* sp., described below, by the strongly papillose surface of the spicules. It differs from *Carphites* spp. in the strong reflection of the rays and their papillose nature.

MATERIAL: All specimens are silicified and were prepared with acid. From P.U. 1r there are three fragments of adult sponges; from P.U. 1rc there are five fragments of juvenile sponges and one of an adult; from P.U. 1 L there is one fragment of an adult.

OCCURRENCE: *Horizon:* Leonardian. *Localities:* Sierra Diablo: P.U. 1r, 1rc, and 1 L. *Biotope:* Basin facies. *Lithotope:* Dark, slabby, spiculiferous, bituminous limestone.

TYPES: Holotype, P.U. No. 78885, from P.U. 1rc; figured paratypes, P.U. Nos. 78884, 78896, 78897, 78900, 78901. The holotype is one of the specimens interpreted as juveniles; it was chosen because it showed best the two types of dermal spicules that embody the diagnostic characters of the species.

Dococderma species

Sponge Cooper, 1953, p. 21, pl. 23, fig. 33.

Description: This is a small flat fragment of a sponge showing the dermal layer on both sides; the interior spicules are revealed in one area where the dermal layer has been removed. The dermalia are stout pentacts up to 8 mm. across, with rays as much as 0.5 mm. thick. The tangential rays are reflexed, and each bears a single prominent hemispherical knob on its distal surface close to the crossing. A similar knob surmounts the crossing in place of the distal ray. The spicules are in parallel orientation and are closely spaced so that their rays overlap for much of their length. The interior spicules seem to be mostly small oxeas, a millimeter or so long, together with some docodermatid triacts of similar size. The gastral layer is not visible, unless one side of the specimen represents the cloacal surface, in which case the gastralia would be identical to the dermalia.

The presence of large dermalia with stout, reflexed, tangential rays, which bear distal processes, is the reason for assigning this fragment to *Dococderma*. It is closest to *D. papillosum* of the present collection, from which it differs in being less papillose and in lacking the secondary polyactinal dermalia. Some of the dermal spicules of juveniles of *D. rigida* are very similar to those of the present form (for example, the spicule third from the left in pl. 40, fig. 1). Nearly identical spicules have also been found in the Pennsylvanian Magdalena formation, from Arcente Canyon, near Alamogordo, New Mexico.

The present specimen (U.S.N.M. No. 116638) is from the Guadalupian rocks exposed near El Antimonio, western Sonora, Mexico; it was obtained from limestone beds of the *Anidanthus* zone at U.S.N.M. 806n.

CARPHITES Finks, new genus

Diagnosis: Dermalia smooth-surfaced hexacts or pentacts, their tangential rays not reflexed; gastralia absent; supradermal mesh of spicules like those of the interior; interior spicules triacts, oxeas, and strongyles, occurring in groups of parallel spicules.

Discussion: The two species of this genus have been separated on the form of the dermalia and the kinds of larger internal spicules. As is *Dococderma*, this genus is characterized by possession of unusually large dermal spicules. It is differentiated from *Dococderma* by the simplicity of these spicules, which almost totally lack distal excrescences, extra rays, or strongly reflexed tangential rays. Also the dermal skeleton is not fused into a continuous, rigid structure. Its closeness to *Dococderma*, however, is emphasized by the rare occurrence of spicules with such features. The species of *Carphites* are closer to *Dococderma papillosum* than to the more elaborately specialized *D. rigida*. Indeed, it is possible to set up a morphologic series of sponges having the same basic structural plan but showing a decreasing specialization of the dermalia, namely: *Dococderma rigida*, *D. papillosum*, *Carphites plectus*, *C. diabloensis*, and *Endoplegma calathus*. The last-named species apparently lacks triacts and has been assigned tentatively to the family Dictyospongiidae, members of which it resembles in its external shape. There seems to be no significant overlap, in the present material, between successive members of this series, but more complete material may conceivably require merging of some of the categories.

Genotype: *Carphites plectus*, new species.

Included Species: *Carphites plectus*, new species, *C. diabloensis*, new species.

Occurrence: Basal Leonardian through lower Guadalupian (Brushy Canyon), Glass Mountains, Sierra Diablo, Guadalupe Mountains.

Carphites plectus Finks, new species

Plate 43, figures 1, 2, 5, 6; plate 44, figure 1;
plate 46, figures 3, 6–8

Diagnosis: Dermalia hexacts mostly with very short distal ray; larger interior spicules triacts.

Description: This species was probably a large, thick-walled, vasiform sponge with a root tuft, but it is known only from fragments. The holotype appears to contain part of the oscular rim and shows that the outer surface curved inward at the top of the sponge to meet the cloacal surface almost at right angles. The body wall is built of triacts parallel to the surface. It is differentiated into two layers, the outer containing only small triacts, in which the large dermal hexacts are embedded, and the inner containing both large and small triacts. The whole wall, on the largest fragments, is about 15 mm. thick, the outer layer occupying 3–6 mm. of this thickness. The large dermal hexacts are in approximately parallel orientation and so closely spaced that they overlie one another, with the overlapping tangential rays outlining mesh spaces smaller than half of the ray length. These spicules are 3–20 mm. across, the smaller generally exterior to the larger. The thickness of the rays relative to their length increases with the size of the spicule, those of the larger being highly conical and as much as 2.5 mm. in diameter near the crossing. The distal ray is usually in the form of a short, blunt cone, but the rays of the deeper spicules may be nearly as long as the tangential rays. The proximal ray is frequently longer than the others and penetrates well into the inner layer of the body wall. On a minority of spicules the distal ray is replaced by a cluster of a few spherical knobs. A few dermalia bear a fifth tangential ray which may be reflexed. On some of the smaller dermalia one or more of the tangential rays may be missing, reduced, or bent out of rectangular alignment.

The triacts of this sponge range from 1 to 7 mm. in length, along their principal axis, and from 0.02 to 0.50 mm. in ray diameter; the rays are proportionately thicker, with respect to length, in the largest triacts. The principal axis may be straight or gently curved, and, if curved, the side ray may lie on the convex or the concave side. The side ray may be at right angles to the principal axis but is more often oblique. These spicules commonly occur in groups of a half dozen or more, with their rays nearly coincident. Such groups may be organized into larger bundles, parallel to the sponge surface and 0.5–1.0 mm. wide. In these bundles the principal axes of the triacts are parallel and overlap laterally. The bundles may cross one another in separate planes, or they may branch in the same plane; in the latter case the branching generally coincides with the point of origin of the side rays of the constituent triacts. Either type of intersection may be at right angles or at an oblique angle. The circular parietal gaps are outlined by bundles which intersect obliquely or which are actually curved. In the outer layer of the body wall a rectangular pattern is more pronounced, for the tangential rays of the dermal hexacts are accompanied, and more or less coated, by triact bundles and similarly oriented, independent bundles form a subquadrate mesh between the hexacts. Exterior to the dermal hexacts, a still finer supradermal mesh is locally preserved. It is formed by very small triacts, 1 mm. long and 0.02 mm. thick, which are grouped into bundles less than 0.5 mm. in diameter (see pl. 43, fig. 2). The triacts of the main bundles of the body wall are mostly 2–4 mm. long and 0.1–0.2 mm. thick. In the inner layer of the body wall these are accompanied by numerous larger triacts, up to 7 mm. long and 0.5 mm. in thickness. The cloacal surface is lined by these same triacts, and there is no specialized gastral layer. (One modified hexact, which seems to belong, is present on the specimen illustrated in pl. 43, fig. 1.) Comitalia include triacts, curved oxeas, curved strongyles, and simple hexacts, all ranging from 0.1 mm. to 1.0 mm. in diameter.

The parietal gaps appear as subcircular openings, 1–4 mm. in diameter, on both the outer and cloacal surfaces. They seem to anastomose within the body wall. The interior canals on the holotype run obliquely upward and outward, rather than being perpendicular to the surface; this may be related to the incurving of the outer surface at the oscular end.

BIOLOGICAL OBSERVATIONS: At the type locality, U.S.N.M. 703c, and at the essentially equivalent A.M.N.H. 503, there occur several small, partly hollow, more or less ovoid bodies, or fragments thereof, up to 20 mm. in diameter. Most seem to be random accumulations of the spicules that make up much of the rock at these localities, that is, chiefly lyssacine spicules together with a few lithistid desmas and protriaenes. They may have drifted together about a stem, shell, or other body now missing, or conceivably may have been gathered together by some animal as an agglutinated shell. Two or three of them, however, consist entirely of the interior spicules of *Carphites* organized in the characteristic interlacing bundles and accompanied by one or two large dermal hexacts or pentacts. One of these is illustrated in plate 43, figure 3. The fact that the spicule bundles appear to be parallel to the surface on all sides of this rounded specimen suggests that it may be a complete individual. If this is true, the specimen could be interpreted as a juvenile. The dermal pentact, however, is disproportionately large. This particular individual may possess large oxeas as well as triacts, and the dermal spicule lacks a distal ray, which would place it in the species *C. diabloensis* rather than in *C. plectus*.

Discussion: This species is distinguished from *C. diabloensis* by its lack of large oxeas, by the presence of larger triacts, by the seemingly universal presence of a sixth ray on the dermalia, and by the greater thickness of the dermal layer. At the type locality, and at the essentially equivalent A.M.N.H. 503, isolated hexacts of identical size and form are quite common and very likely come from individuals of this species. Associated with them are pentacts and stauracts of the same size (pl. 46, figs. 6–8). Possibly these latter types of spicules also come from this species, but the presence of hexacts would still be one of the diagnostic characters. Large hexacts are also found at A.M.N.H. 369a and A.M.N.H. 505; they are probably safely referable to *Carphites* and, with reservations, to this species.

Material: Two fragments of the body wall plus small clumps of spicules of a doubtful nature plus numerous isolated dermalia and triacts. All are silicified and were recovered from insoluble residues.

Occurrence: *Horizons:* Leonardian and possibly Guadalupian. *Localities:* Glass Mountains; U.S.N.M. 703c, A.M.N.H. 503, possibly A.M.N.H. 505; Guadalupe Mountains, possibly A.M.N.H. 369a. *Biotopes:* Mixed basin and patch-reef facies; basin facies. *Lithotope:* Dark spiculiferous limestones.

Types: Holotype, U.S.N.M. No. 127661; paratype, U.S.N.M. No. 127662a, from U.S.N.M. 703c.

Carphites diabloensis Finks, new species

Plate 42, figure 8; plate 43, figures 3, 4

Diagnosis: Dermalia pentacts with no trace of distal ray; larger interior spicules oxeas.

Description: The sponges represented by these fragments were vasiform bodies with root tufts and attained heights in excess of 90 mm. The body wall is 4–6 mm. thick. One of the fragments has a circular opeining at one end, 10 mm. in diameter, which may be the osculum, though it seems somewhat small for the size of the fragment. The dermal spicules are stout and smooth-rayed pentacts with no trace of a distal ray. They measure 3–20 mm. across, and the rays are 0.5–2.0 mm. thick near the crossing. The tangential rays are not reflexed, or are reflexed less than 10 degrees. The dermal layer is essentially one spicule thick, although the smaller spicules are often exterior to, and somewhat overlap, the larger. The dermalia are in parallel orientation. The interior spicules consist of small and large oxeas, small triacts, and small strongyles. They are organized into bundles 0.5–1.6 mm. wide, which run parallel to the surface. Many intersect at right angles parallel to the dermal spicules, but others run diagonally or curve about the parietal gaps. There seems to be no specialized gastral layer, though a small pentact and a small stauract were found in this position. The root-tuft monaxons seem to extend up well into the body and may have formed a partial lining of the cloacal surface. The oxeas of the interior of the body wall range in length from 0.3 mm. to more than 15 mm.; their diameters, which to some extent are independent of their length, range from 0.02 mm. to 0.60 mm. The smallest oxeas are distinctly curved. The triacts, the principal axis of which may or may not be curved, and of which the side ray may or may not be at a right angle, are 0.26–0.80 mm. long and 0.026–0.10 mm. thick. Small curved strongyles, some quite fat, range in length from 0.2 mm. to 0.5 mm. One small umbel was found among the loose interior spicules; it is 0.3 mm. long, with a tapered shaft and a hemispherical cladome bearing short triangular clads. A fragmental anadiaene, like those present in "Lyssacine, species 1," was also found. The last two spicules may or may not belong to the specimen. A sphaeraster, or oxyhexaster, some 0.05 mm. in diameter, was also recovered. The circular parietal gaps are 1–6 mm. in diameter; they tend to be somewhat larger on the cloacal surface than on the exterior.

Discussion: These fragments are in many respects intermediate between *Carphites plectus* and *Endoplegma calathus*. There may be more of a morphological overlap between the three species than the present incomplete material permits us to observe. As does *Endoplegma calathus* the present species consists of a single layer of large simple pentacts over an interior spiculation of monaxon bundles. The dermalia of *Endoplegma*, however, do not attain the larger sizes seen in *Carphites*, and their rays are relatively more slender. Also the interior spiculation of *Endoplegma*, unfortunately not well preserved, shows no trace of docodermatid triacts. The fragmental specimens of *Carphites plectus* agree with *C. diabloensis* in the size and ray thickness of the dermalia, but a reduced sixth ray is almost always present in *C. plectus*, and the dermal layer is more than one spicule thick. *Carphites plectus* also differs from the present species in that its triacts are mostly much larger than any isolated from *C. diabloensis*. *Carphites diabloensis*, with one exception, is restricted to the basin facies of the Bone Spring formation in the Sierra Diablo, as is its associate, *Docoderma papillosum*, from which it is readily distinguished by the simplicity of the dermalia. The exception to this geographic restriction is the single small specimen from Word limestone number 1 in the Glass Mountains, A.M.N.H. 503, which is illustrated in plate 43, figure 3, and is discussed above under *C. plectus*. This appears to have the two diagnostic features of this species, namely, large interior oxeas and lack of a distal ray on the dermal spicule; it is, however, a dubious object at best. At U.S.N.M. 703c and A.M.N.H. 503, there are many isolated docodermatid dermal spicules, which are discussed below. Among them are large pentacts lacking a sixth ray, which could belong to a form such as *C. diabloensis*, but a definite assignment cannot be made in the absence of the interior spiculation.[1]

MATERIAL: Five fragments plus isolated spicules from P.U. 1r, two fragments from P.U. 1rc, and one doubtful specimen from A.M.N.H. 503. All are silicified and prepared with acid.

OCCURRENCE: *Horizon:* Leonardian. *Localities:* Sierra Diablo: P.U. 1r, P.U. 1rc; Glass Mountains: possibly A.M.N.H. 503. *Biotope:* Basin facies. *Lithotope:* Dark spiculiferous limestone.

TYPES: Holotype, P.U. No. 78891; paratypes, P.U. Nos. 78890, 78892, 78893, 78894.

ACANTHOCORYNA FINKS, NEW GENUS

DIAGNOSIS: Dermalia and gastralia include pentacts with very stout, fusiform, proximal ray, and conical branching spikes in place of distal ray; choanosome including interlacing bundles of oxeas parallel to surface; triacts apparently absent.

DISCUSSION: The highly distinctive and specialized dermal and gastral spicules of this fragment have prompted its assignment to a new genus. The strong dermal specialization, particularly the presence of elaborate distal excrescences, and of what amounts to extra tangential rays on the dermal spicules favor inclusion of this form in the superfamily Brachiospongioidea. The extreme stoutness and strong taper of some of the rays of the dermal and gastral spicules suggest further a relationship to the family Docodermatidae. However, there is no trace of the peculiar triacts found in the other genera assigned to that family, their place being taken by oxeas alone. The genus is here assigned tentatively to that family despite its lack of triacts.

Because the present genus is monobasic, the selection of generic characters is somewhat arbitrary. Those included in the above diagnosis are more or less comparable with those at the generic level in other members of the family. Comparisons of the present genus with related forms are reserved for the discussion of the species below.

GENOTYPE: *Acanthocoryna stauroma*, new species. This is the sole species.

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[1] Additional material, possibly belonging to this species, was collected from U.S.N.M. 703, in the Glass Mountains, after the present paper was completed. The material consists of five large fragments of the body wall, 2 mm. to 10 mm. thick, which contain portions of the root tufts. The dermalia are simple pentacts in parallel orientation, agreeing with those of the type lot of *Carphites diabloensis*, but the interior spicules are chiefly large triacts like those of *C. plectus*. At least some of the root-tuft spicules, and possibly all of them, are greatly elongated triacts rather than monaxons. Small spicules, probably comitalia, include triacts, hexacts, curved oxeas, and curved strongyles. These specimens strongly suggest that *Carphites diabloensis* and *C. plectus* may ultimately prove to be conspecific. Some of the new fragments have dermalia as slender as those of *Endoplegma calathus*. As their occurrence is approximately at the type locality of *Endoplegma calathus*, that species may also prove to be equivalent to *Carphites plectus* when its interior spicules are discovered.

Acanthocoryna stauroma Finks, new species

Plate 44, figures 2–6; plate 45, figures 1–6

DIAGNOSIS: Special dermal spicules having long, slender, tangential rays; the largest spikes of the distal rosette bisecting the angles between the tangential rays; the other spikes usually bearing branches; the proximal ray may bear a ring of spikes just below the crossing; the gastral spicules differing from the dermalia in having shorter tangential rays and in lacking the distal rosette; the latter replaced by a short process on the distal surface of each tangential ray near the crossing, and in some spicules also by a similar distal process on the crossing itself; the ring of spikes on the proximal ray just below the crossing almost always present.

DESCRIPTION: This species is represented by a somewhat rectangular fragment, 45 mm. by 60 mm., of a large, thick-walled sponge. The main skeleton is composed of simple hexacts, in more or less parallel orientation near the inner and outer surfaces but less regularly disposed on the interior. Their rays are rather stout and tapering. At both outer and cloacal surfaces the spicules are modified into pentacts, with a relatively long proximal ray, or into stauracts. All these spicule types are 0.2–4.0 mm. wide, and their rays are 0.1–0.5 mm. thick. The interior of the body wall also contains numerous smooth fusiform oxeas of variable length and width, organized into long bundles parallel to the sponge surface but intersecting at various angles. The bundles are 0.5–1.0 mm. thick, and the individual oxeas are 0.05–0.2 mm. thick and 0.5–10.0 mm. long. In addition to this main skeleton there are highly specialized dermalia and gastralia of unusual form. Both types are pentacts with a remarkably stout and long proximal ray; this ray is strongly fusiform, with its thickest part nearer the crossing than the tip. In the spicules that are here identified as dermalia, the proximal ray is 1.0–5.0 mm. long and up to 0.5 mm. thick at its thickest part. The four tangential or dermal rays are well developed, and the spicule measures 1.0–5.0 mm. across them, tip to tip. Each ray is 0.1–0.5 mm. thick. In the position of the aborted distal ray, there is a cluster or rosette of short, stout, conical spikes, which branch from one another and radiate upward and outward from the crossing. The tip of this cluster stands about 0.5 mm. above the crossing. On many of these spicules, four of the spikes, each about 0.5 mm. long, are nearly in the dermal plane and bisect the angle between the regular dermal rays. On a minority of the dermal spicules, there is a ring of similar spikes around the proximal ray just below the crossing. The proximal rays of the gastralia are somewhat smaller than those of the dermal spicules, generally not exceeding 4.0 mm. in length or 0.3 mm. in thickness. Their tangential rays are very much reduced in length, the whole spicule not measuring more than 1.2 mm. across them. They are also more slender, measuring only 0.1 mm. in thickness. Each tangential ray bears a small protuberance about 0.1 mm. high on its distal surface close to the crossing, and a similar process may surmount the crossing itself. Some of these protuberances may show incipient branching, but there is no development of a rosette of spikes like those on the dermal spicules. A ring of six to eight spikes is almost always developed on the proximal ray a short distance below the crossing. The proximal ray is generally narrower than elsewhere between this point and the crossing. Some loose pentacts were found in the rock associated with this specimen, which may possibly belong to it. They have a fairly stout and long proximal ray and very slender and delicate tangential rays which rise from the crossing at an angle and then branch into two divergent rays in a horizontal plane above the level of the crossing; the distal ray is completely suppressed. These spicules are closest in their form to the gastral spicules.

The dermal surface bears circular to oval pores 1–3 mm. in diameter and irregularly spaced about 2–5 mm. apart. On the cloacal surface there are similar, but smaller pores, 0.5–2.0 mm. in diameter and 1.5–3.0 mm. apart. Within the body wall, as revealed on the sides of the specimen, there are canals 0.5–1.0 mm. in diameter and 0.1–3.0 mm. apart. Canals and pores are in part outlined by the bundles of oxeas. Possibly some of these openings do not represent parietal gaps or true canals, but rather were tubes occupied by symbiotic worm-like organisms, as discussed in the following section.

Biological Observations: Because the specimen is incomplete, the identification of one surface as dermal and the other as cloacal has been made on the basis of spicule form; the larger and more elaborate spicules are assumed to be dermalia, as is the case in all other lyssacine species of the present collection in which the dermal and gastral layers can be identified from the shape of the whole sponge. It is, of course, quite possible that the present species is an exception to this rule. The relative size of the pores on the two sides of the present specimen to some extent contradicts the choice, inasmuch as they are larger on the assumed dermal side contrary to the usual arrangement.

The nature of these pores, however, merits discussion, as there is evidence that some may not be true parts of the sponge. On the assumed dermal surface there are two meandering grooves of hemicylindrical cross section sunk into the surface. They are each 2 mm. wide and lined with small monaxons, or possibly monaxon fragments, aligned across the length of the groove. One of these grooves penetrates into the interior of the body wall in two places and ends at the broken edge in a circular opening, similar in appearance to the canals that penetrate other parts of the sponge. These grooves are almost certainly not functional parts of the sponge. They could be the former sites of stem-like foreign bodies overgrown by the sponge and coated by the sponge itself with small monaxons. More likely, however, they are the agglutinated tubes of epoecious, worm-like animals. Unfortunately it is not possible to demonstrate here that the monaxons lining them are fragmental, which would effectively prove their agglutinated origin. If, as seems probable, they are indeed worm tubes, then some of the other pores on the surface may also represent openings of worm tubes.

Discussion: This species is quite distinct from any other in the collection. The surficial spicules are unique. The hexacts and related spicules of the main skeleton, on the other hand, are indistinguishable from those of many other lyssacines. The organization of the bundles of oxeas corresponds to a similar structure in *Endoplegma* and in *Carphites* but without the rectangular arrangement shown in those genera. In *Carphites* the bundles include triacts, which are altogether absent here. However, as stated under the discussion of the genus, *Carphites* and *Docoderma* may be the closest relatives of this species among the sponges of the present collection.

The insoluble residues from the same locality have yielded several unusually large oxeas, some as much as 40 mm. long and 2.5 mm. thick. Some of them (U.S.N.M. No. 127664, pl. 46, fig. 1) are quite smooth, gently curved, and equally pointed at both ends. Others (U.S.N.M. No. 127665, pl. 46, fig. 2) are blunter at one end, which is covered with closely set conical spines, projecting somewhat distally and each about 1 mm. long. From 2 to 15 mm. of the spicule may be thus covered. The thickness of the spicule and the form of the spines are reminiscent of the surficial spicules of *Acanthocoryna*, though they are by no means the same type of spicule. Whatever their specific affinities, they are very probably derived from some docodermatid sponge. An identical spinose form was found adherent to the surface of "Lyssacine, species 1," but it almost certainly does not belong to that form.

Material: One silicified fragment, prepared with acid.

Occurrence: *Horizon:* Uppermost Leonardian (Word limestone number 1). *Locality:* U.S.N.M. 703c, Glass Mountains. *Biotope:* Mixed basin and patch-reef facies. *Lithotope:* Dark, slabby, spiculiferous limestone.

Holotype: U.S.N.M. No. 127663.

STIODERMATIDAE Finks, new family

Diagnosis: Spicules of body wall almost entirely slender-rayed, regular hexacts, some spinose, in non-parallel alignment and never strongly fused with one another; dermalia similar but with distal, and often tangential, rays locally swollen; supradermal mesh, if present, non-quadrate and not covering the parietal gaps; gastral specialization weak, but small oxeas in the plane of the surface may be present; well-developed root tuft present.

Discussion: The basis for the understanding of this family is the abundant and fairly complete material assigned to the new genus and species *Stioderma coscinum*. In the light of this knowledge, a number of isolated spicules and fragments previously described in the literature have been assimilated into the family, at least tentatively. None of these, however, permits much understanding of the range of variation from the central type, so that the family characters remain completely conjectural, and the group serves simply as a convenient means of separating *Stioderma coscinum* from the other brachiospongioids.

In many ways *Stioderma* is closer to *Brachiospongia* than are the other brachiospongioids. The internal spiculation of irregularly oriented, simple hexacts, some of them spinose, is a character shared by the two genera but not found in the other members of the superfamily. Also, the peculiar shape of the dermalia in *Stioderma* is but an exaggerated form of the corresponding spicules in *Brachiospongia.* The presence, in *Stioderma,* of a root tuft, as well as of a peculiar type of supradermal mesh, makes advisable a more than generic separation between the two. A similar separation of *Stioderma* from the other brachiospongioids is indicated by the peculiar nature of its dermalia and its internal spiculation.

Of the previously described forms assigned here to this family, certainly the most important is *Hyalostelia* Zittel, 1878, for it is possible to interpret that genus as a senior synonyn of *Stioderma.* The writer has chosen to avoid such a step, because *Hyalostelia* is known only from isolated spicules which give little indication of the organization of the whole sponge. The genus was originally established by Zittel (1878, p. 185) for isolated spicules, root-tuft fragments, and a small coherent portion of a lyssacine skeleton, which were found together in the lower Carboniferous limestones at Cunningham Baidland, Scotland, and were first described as *Acanthospongia smithii* by Young and Young (1876, pp. 36–38). The original assignment of the material to *Acanthospongia* M'Coy, 1862, was rightfully corrected by Zittel, for the Silurian genotype of that genus, *A. siluriensis* M'Coy, shows no characters that would link it closely to the Carboniferous material. The type material of *Hyalostelia* was subsequently restudied, described, and figured by Hinde (1888a, p. 158, pl. 6).

It consists of: (1) isolated, simple hexacts and pentacts; (2) fragments of bundles of parallel monaxons, probably portions of root tufts; (3) isolated monaxons of similar size, terminating in four recurved clads; (4) isolated hexacts with swollen distal and tangential rays, almost identical to the dermal spicules of *Stioderma coscinum*; and (5) a small, coherent portion of a dermal or gastral layer, composed chiefly of stout-rayed pentacts mostly bearing a small knob in place of the distal ray. There is no indication that these all belonged to the same sponge, other than their common association and similar size, except that some of the recurved clads on the root-tuft monaxons have swellings like those on the *Stioderma* type of hexacts. The swollen hexacts, Hinde's illustrations of which are reproduced in the present paper on plate 49, figures 3 and 4, must be assigned to *Stioderma* as that genus is here defined. The other isolated spicules and root-tuft fragments are not incompatible with *Stioderma* but could belong to almost any lyssacine. The small, coherent fragment of surface pentacts, however (reproduced here on pl. 49, fig. 5, from Hinde's illustration), is different from anything seen in *Stioderma coscinum.* The stout, but smoothly tapering, tangential rays of these pentacts, and their much reduced distal knobs, set them apart from the known dermalia of *Stioderma* as well as from the other spicules in the type material of *Hyalostelia.*

Inasmuch as this type material of *Hyalostelia,* from which, incidentally, no holotype has ever been selected, may be heterogeneous and gives us little idea of the characters of the whole sponge, the purposes of taxonomic clarity would best be served by establishing the new genus *Stioderma* on the basis of the more complete material of the present collections and allowing *Hyalostelia* to lapse as a taxonomic entity. Such would be accomplished by restricting the name, *Hyalostelia,* to the small, coherent fragment of surface pentacts illustrated by Hinde (1888a, pl. 6, fig. 1) and in the present paper (pl. 49, fig. 5), which could be selected as lectotype. The present writer is not, however, making such a selection here. The swollen hexacts of *Hyalostelia smithii,* and possibly the isolated anatetraene root-tuft spicules, can be referred to *Stioderma* sp., but the remainder of the type lot must remain unrecognizable. Should a future discovery show all the spicules of *Hyalostelia smithii* in a physically coherent association, then *Hyalostelia* could be revived and *Stioderma* either redefined or sunk in synonymy. The addition of a new name to the literature should certainly be approached with caution, but retention of *Hyalostelia* on the basis of the present type lot can only lead to confusion and will encourage the unfortunate and hitherto prevalent practice of assigning to this genus isolated spicules that resemble one or another of the type specimens. Weller (1930, p. 244) recognized that the swollen hexacts were the only spicules of the type lot that were not known from many other widely different genera of lyssacines and restricted his conception of the genus to forms with such spicules. In the present writer's opinion, this conception would be more secure taxonomically if it were founded on the material of *Stioderma* rather than on *Hyalostelia*. Weller's *Hyalostelia diabola* (1930, p. 242) should be referred to *Stioderma*.

As for other material in the literature, nothing can be referred with certainty to this family. The small fragment bearing surface pentacts in the type lot of *Hyalostelia smithii* may represent another genus that belongs here. The isolated spinose hexacts that Weller made the basis of his genus *Rhakistella* (Weller, 1930, p. 243) may be the interior spicules of a stiodermatid, possibly from the same sponge as the *Stioderma* type of dermal spicules that occurred with them and that Weller called *Hyalostelia diabola*. They are similar to some found in *Stioderma coscinum* of the present collections. The genus *Acanthactinella* Hinde, 1888a, was established for spinose hexacts with bifurcate rays similar to those called *Rhakistella*, but their larger size and coarser form do not favor a close relationship. The spinose hexact illustrated by Hinde (1888a, pl. 9, fig. 13) may belong here, and the same may be said of most of the late Paleozoic spicules referred to the various species of *Hyalostelia*. However, no isolated spicules, with the exception of the dermalia of *Stioderma*, can be considered diagnostic of this family in themselves.

The genera *Pyritonema* M'Coy, 1850, and *Acestra* Roemer, 1861, which were based on root-tuft fragments, were cited by Hinde (1888a, p. 109) as synonyms of *Hyalostelia*. These genera are unrecognizable and should be abandoned. It remains to be pointed out that De Laubenfels (1955, p. E93) assigned *Hyalostelia* to the family Astraeospongiidae on the ground that octactinellid spicules are present. The present writer knows of no evidence in the literature that such is the case.

The new genus *Pileolites* deserves mention here, as the distal ray of its dermal spicules is reduced to a large spherical knob as in *Stioderma*. The internal organization of *Pileolites*, however, is so very different that this single resemblance is best considered an independent development.

INCLUDED GENERA: *Stioderma*, new genus, equals *Hyalostelia* Zittel, 1878, in part (Mississippian to Permian, Europe and North America); ? *Hyalostelia* Zittel, 1878, in part (Mississippian, Scotland); ? *Rhakistella* Weller, 1930 (Pennsylvanian, North America).

STIODERMA FINKS, NEW GENUS

Hyalostelia ZITTEL, 1878 (in part).

DIAGNOSIS: Distal ray of dermalia spherical or club-shaped and much larger than main shaft of ray.

DISCUSSION: Until species other than the genotype can be known from reasonably complete material, it will not be possible to arrive at a clear idea of what constitutes generic and specific characters in either the family or the present genus. The general form of the dermalia is here cited as a generic character by analogy with similar distinctions in the family Docodermatidae. Under this definition the spicules of *Hyalostelia smithii* (Young and Young) illustrated in Hinde, (1888a, pl. 6, figs. 1f, 1g) must be referred to this genus; the root-tuft spicules shown in figures 2e–k on the same plate in Hinde may belong to the same species, but the rest of the material is unidentifiable, and the specimen shown in figure 1 of the same plate in Hinde cannot be referred to *Stioderma*. The dermal spicules named by Weller *Hyalostelia diabola* (Weller, 1930, p. 242, pl. 16, figs. 1–18) must also be referred to *Stioderma*. It is impossible to recognize specific characters in either of these named forms. No consistent characters can be recognized that would distinguish them from the equivalent spicules of *Stioderma coscinum*. These two species are best held in abeyance until more complete material from the type localities is available.

GENOTYPE: *Stioderma coscinum*, new species.

INCLUDED SPECIES: *Stioderma coscinum*, new species; *Stioderma diabola* (Weller, 1930); *Hyalostelia smithii* (Young and Young, 1877), in part only.

OCCURRENCE: Mississippian (Scotland); Pennsylvanian and Permian (central and southwestern United States).

Stioderma coscinum Finks, new species

Plate 47, figures 1–9; plate 48, figures 1–9; plate 49, figures 1, 2, 6, 7

DIAGNOSIS: Sponge a thin-walled cup with numerous large, circular, parietal gaps; dermal layer reflexed internally at the oscular rim; dermalia of two general sizes, the smaller exterior to the larger and radially disposed about them; in adults, the small dermalia fusing with the distal knobs of the larger to form a continuous rigid net; interior hexacts both smooth and spinose; gastral surface bearing small oxeas oriented randomly in the plane of the surface.

DESCRIPTION: The body of this sponge is goblet-shaped. Beginning from a cylindrical base surrounding the root tuft, it expands upward rapidly to a point about one-fourth of the distance from the top, whence it contracts slightly towards the rim of the broad osculum. The most completely preserved large specimen (pl. 47, fig. 1) is 150 mm. high, not including the root tuft which projects an additional 80 mm. beyond the base. The width of this specimen, which may be somewhat exaggerated because of crushing, is 40 mm. at the base, 150 mm. at the widest point, and 110 mm. at the osculum. A still larger example, not illustrated here, was more than 160 mm. high, but its remaining dimensions cannot be determined accurately because of incompleteness and distortion. The smallest specimen in the collections (pl. 47, figs. 4–6) measures approximately 7 mm. by 15 mm. at its widest point; its body originally stood some 35 mm. high. The body wall is pierced by numerous circular parietal gaps, the size and spacing of which vary with the dimensions of the whole sponge, as well as with their position on the sponge body; those on the main part of the body are generally larger than the ones near the basal and oscular ends. The total range in size of these openings is 0.3–6.0 mm., and their spacing, center to center, varies from 0.5 mm. to 9.0 mm. The surface of the sponge has a strikingly pebbled texture, produced by the closely spaced spherical knobs representing the distal rays of the dermal spicules. The body wall, as preserved, is generally less than 1 cm. thick, and on some small fragments as thin as 0.5 mm., but this thickness has probably been reduced, in many cases, from an originally greater one, by loss of the loosely united interior spicules. On one fragment in which the interior spiculation seems to be complete, the total thickness of the wall is 15 mm. The whole body wall is sharply doubled back on itself at the oscular rim, carrying the pebbled exterior surface, with its parietal gaps, down into the cloaca for several millimeters.

The dermal spicules are hexacts with rays of subequal length. The distal ray is universally enlarged into a spherical or club-shaped knob which may be so large as to rest directly on the crossing. One or more of the tangential rays may bear a similar, but smaller, swelling, more expanded on the distal surface of the ray and generally not involving its tip. The dermalia are of two general sizes, the smaller ones occupying the spaces between the spherical knobs of the larger spicules, apparently exterior to their tangential rays. The small dermalia thus constitute a kind of supradermal layer. The dimensions of the spicules vary somewhat according to the total size of the sponge, but on most of the larger specimens the knobs of the large dermalia are about 1.0 mm. in diameter, and those of the small spicules one-fourth as large. The total size range of the knobs, both large and small, is 0.2–1.8 mm. The spacing of the spicules is quite variable, but the knobs tend to be separated by spaces equal to their diameter or less. The orientation of the tangential rays of the spicules is difficult to determine; they seem to be generally non-parallel, and the smaller spicules tend to take up a radial arrangement about the knobs of the larger. It is also difficult to measure the total width of the spicules across their tangential rays; the total size range seems to be 0.5–3.0 mm. On the largest, presumably adult, sponges, the tangential rays of the small dermalia fuse with the adjacent knobs of the large spicules, as well as with one another, to form a continuous, rigid mesh. Because of the radial orientation of the small spicules about the large ones, the knobs of the latter appear to give rise to a circle of a dozen or so fine rays. Secondary synapticulae may be involved in this structure, for some of the radial elements pass directly from one large knob to another without branching. Also, possibly these are small dermalia in which one tangential axis has been suppressed. The whole structure produced by this fusion may be considered a kind of supradermal mesh; it is probably not homologous, however, to the supradermal mesh developed in the Brachiospongiidae and Docodermatidae, for it is not quadrate and does not cover the parietal gaps.

The internal spiculation consists of several layers of loosely united hexacts in generally non-parallel orientation. Individual hexacts may be distorted where they border on one of the parietal gaps. Most of the hexacts are smooth-rayed, but a few spinose examples were isolated from U.S.N.M. No. 127671, from U.S.N.M. 702; this specimen has the best-preserved interior spiculation. The size of the interior hexacts is about the same as that of the dermalia; most are from 1.0 mm. to 2.0 mm. in total width, the slender rays 0.1–0.2 mm. thick.

The gastral surface is poorly known. It seems likely that no coherent layer comparable to that of the dermal surface is ever developed. On the relatively well-preserved specimen mentioned in the preceding paragraph no specialized gastralia have been found. A possible gastral specialization may be represented by the apparent shortening or absence of the distal ray on some of the innermost hexacts (see pl. 49, fig. 2). They may, however, have merely been broken off during the preparation of the specimen. On the fragments from A.M.N.H. 389 and A.M.N.H. 502 (see pl. 47, fig. 3), the inner surface contains smooth oxeas interspersed among the hexacts and randomly oriented parallel to the surface. They are up to 2.5 mm. long and about 0.05 mm. thick and may represent a specialized gastral spiculation. The parietal gaps open directly onto the gastral surface, maintaining the same diameter as on the exterior.

The root tuft is a single bundle of parallel smooth monaxons the diameters of which range from 0.05 mm. to 0.75 mm. The distal ends have not been preserved. The tuft extends upward into the basal cylindrical portion of the sponge which closely surrounds it. It does not penetrate farther into the sponge interior. At U.S.N.M. 707ha a single anatetraene was found, which may be the distal end of a root-tuft spicule of this species, for a single dermal spicule of *Stioderma* was also found here. The rhabdome of the anatetraene was originally longer than the 3 mm. now preserved. The rhabdome is 0.15 mm. thick; the clads are 0.50 mm. long and make an angle of about 25 degrees with the rhabdome.

BIOLOGICAL OBSERVATIONS: Something of the ontogeny of this sponge may be tentatively inferred from the two most completely preserved specimens, namely, the holotype and the small individual A.M.N.H. No. 28087. Both exhibit the same characteristic shape. If we assume that their size difference reflects their ontogenetic stage, then we must conclude that the sponge grows by uniform expansion of the whole body, intercalating new spicules between those already formed. If this is the case, then formation of the rigidly fused dermal mesh in adult individuals must effectively put an end to further growth. This inference is supported by the fact that only in the larger individuals, or in the fragments of which the large parietal gaps and spicules suggest they are from such individuals, do we find the development of this rigid mesh. The manner of growth of this species, therefore, differs from that seen in lithistids and some dictyonines, in which new layers of spicules can be added peripherally to an already rigid skeleton. As does *Docoderma*, in which a similar situation prevails, this species achieves strength at the sacrifice of unlimited growth.

This species is the most widely distributed hexactinellid sponge of the present collections, in terms both of facies and of time. It is likely that these facts reflect an unusual tolerance on the part of this organism to a variety of environmental conditions. It not only occurs in basin-facies rocks, to which most of the other hexactinellids are restricted, but also in the shelf-facies limestone of the Victorio Peak formation, in the patch-reef facies of the Leonard formation, and in the reef limestone of the Goat Seep formation. It is also the only hexactinellid so far known from the clastic shelf-facies beds of the Texas Pennsylvanian. Possibly the relatively rigid dermal skeleton permitted it to survive in water more agitated than that of the basin environment. The unusually large parietal gaps may be a correlative adaptation, allowing a free flow of currents through an otherwise dense skeleton, thereby reducing physical stresses on the body. It is also likely that the very coherence of its skeleton has rendered it more easily preserved as a fossil.

DISCUSSION: The holotype (pl. 47, fig. 1) shows almost the entire form of the whole sponge, with the exception of the oscular rim and the very tip of the root tuft. It is actually half an individual, lying flat in the bedding plane, so that one side reveals a complete sagittal section of the sponge, and the other side a portion of the exterior surface. The specimen was not removed from the matrix for fear of damaging it extensively. The small paratype from A.M.N.H. 369 (pl. 47, figs. 4–6) shows the oscular end more clearly, including the characteristic reflection of the body wall into the cloaca; this feature is also preserved on the fragments from D.W.B. 1144 (pl. 48, figs. 3–5) which bear in addition a well-developed, supradermal mesh. None of the foregoing preserves much of the interior spiculation, but this is shown to excellent advantage on the specimens from U.S.N.M. 702 (pl. 48, figs. 7, 8; pl. 49, figs. 1, 2). The fragments from A.M.N.H. 512 (pl. 47, fig. 3) and A.M.N.H. 389 bear, in addition, the small oxeas that may be a gastral spiculation. All these specimens together provide us with a reasonably complete knowledge of the structure of this species, a knowledge that is confirmed by the many other fragments available in the collections. No consistent differences could be observed in all this material that would permit the recognition of more than one species. The stratigraphically oldest specimen (pl. 48, fig. 2), a fragment from the Dickerson shale of Demoinesian age, has larger spherical knobs and parietal gaps than the others. Such could be a specific difference, as the great difference in horizon certainly suggests, but it could be ascribed equally well to a difference in ontogenetic stage. The fragment from Y.P.M. 502 (pl. 47, figs. 7, 8) has very small dermalia and parietal gaps, although it appears to be part of a large individual. However, this is the basal portion of the sponge body which covers the root tuft and probably represents an extreme case of the generally observed tendency towards reduction in parietal-gap size at the upper and lower ends of the body. This points up the difficulty of evaluating the significance of variation in isolated spicules or in fragments of the body wall. The size of both spicules and parietal gaps can be seen to depend on ontogenetic stage (that is, on total size of the individual) as well as on their location in the body of the sponge. The local variation can be seen in plate 47, figure 4, and this same specimen shows, over all, a generally smaller size of all its elements than that seen in the larger individuals.

Root tufts present another problem. Those attached to fragments of the body wall can, of course, be identified with certainty, but the tufts of this species are so simple and generalized that there is no way of identifying isolated examples. Such root-tuft fragments, not incompatible with those of *Stioderma coscinum*, are known from several localities at which no other evidence of *Stioderma* is present. They are listed below with the express reservation that some, or more likely all, of them do not pertain to this species.

MATERIAL: All the specimens are silicified, and most have been prepared to some extent with acid. Three nearly complete specimens are available from U.S.G.S. 14444 (holotype), A.M.N.H. 369, and D.W.B. 1146. One or more sizable fragments of the body wall are available from each of the following localities: A.M.N.H. 389, 512; U.S.N.M. 518a, 702, 707q; U.S.G.S. 6656, 6938, 8548; Y.P.M. 502; P.U. 1rc; and D.W.B. 1144. Isolated dermalia are known from U.S.N.M. 707ha and P.U. 20i, as well as from many of the preceding localities. Unattached root-tuft fragments, which may or may not belong to this species, occur at P.U. 10up, 20f, 29, 53b, 53g, 60a, 70c; Y.P.M. 92, 93, 222; and D.W.B. 1146.

OCCURRENCE: *Horizons:* Desmoinesian; Leonardian, Guadalupian. *Localities:* Texas, New Mexico (see preceding paragraph for specific localities). *Biotopes:* Basin, mixed basin-patch reef, patch-reef, reef, and shelf facies. *Lithotopes:* Light quartz sandstone (D.W.B. 1144, 1146); calcareous shale

(U.S.N.M. 518a); light, partly bioclastic limestone (U.S.G.S. 8548, 14444; U.S.N.M. 702); and dark limestone (remaining localities).

TYPES: Holotype, U.S.N.M. No. 127666 (from U.S.G.S. 14444, Victorio Peak formation, Sierra Diablo); paratypes, A.M.N.H. Nos. 28087, 28087/1, 28087/2, 28087/3, 28087/3:1, 28087/3:2, 28087/4, 28087/4:1; U.S.N.M. Nos. 127669, 127670, 127671a, 127671b; P.U. No. 78903; Y.P.M. No. 19593.

STROMATIDIIDAE FINKS, NEW FAMILY

DIAGNOSIS: Skeleton built of layers of pentacts with dichotomously branching rays; spicules within each layer fused into continuous net; sponge not vasiform and parietal gaps not present.

DISCUSSION: The skeletal structure of *Stromatidium typicale* Girty, consisting of separate and superposed layers of intricately branched, delicate pentacts, the spicules within each layer continuously fused to one another, is unique among all the hexactinellids and merits assignment to a family of its own. Girty (1909, p. 76) suggested that such a disposition of the species should probably be made but refrained from doing so himself because of the fragmentary nature of the material. The present collections contain somewhat more complete material than was available to Girty, though the form of the whole sponge is still unknown. However, inasmuch as no other known hexactinellid skeleton, constructed of more than one layer of spicules, is composed entirely of pentacts, it seems desirable to establish a separate family for it. Girty placed the genus among the dictyonines because the spicules appeared to be continuously fused in a three-dimensional net. The present material shows, however, that the individual layers are quite separate from one another and that the ensemble does not approach the regular cubic mesh characteristic of the dictyonines. (Some dictyonines have an octahedral symmetry, but such is not the case here either.) It seems better to include this peculiar form among the lyssacines. The development of such a complex net, by the branching and fusion of tangential rays, is not unknown among living lyssacines. Schulze (1887, p. 38) describes a fine, delicate latticework formed on parts of bounding surfaces of the lanuginellid *Rhabdocalyptus mollis* either where the sponge was in contact with solid bodies in the substratum, or about similar foreign objects incorporated within the sponge. These, however, were secondary deposits formed under accidental conditions, whereas in the present species, the latticework is a primary and essential feature of the skeleton. Because of the uniqueness of this skeletal structure, the broader relationships of *Stromatidium* are difficult to assess. It is here tentatively included among the Brachiospongioidea, because pentacts with distal excrescences and branching rays are characteristic of that group. In the other members of that superfamily, however, such features are confined to the surface pentacts and are not found throughout the sponge. Also, the apparent lack of a vasiform shape and of parietal gaps is most untypical of the superfamily.

A word remains to be said about the identification of the primary spicules as pentacts. The spicules are so completely continuous with one another in each layer that individual spicules cannot be isolated. Because of this situation, Girty, while interpreting the spicules as pentacts, suggested that they might possibly be tetracts and the sponge a lithistid demosponge. Such caution seems unnecessary. As Girty himself observed, and as the present writer has abundantly confirmed from a study of all the available material, wherever tangential rays arise from their juncture with a vertical ray, they are four in number and are at right angles to one another and to the vertical ray. The remaining tangential elements, as Girty also observed, may be completely accounted for by the branching of these primary rays. The branching is dichotomous, and the subsidiary rays bifurcate repeatedly until the process is brought to a halt by contact with the rays of adjacent spicules. Possibly secondary synapticulae are also present, and probably some of the pentacts are not equally developed on all sides, but there can be little doubt that this is a hexactinellid sponge (see text fig. 77).

INCLUDED GENUS: *Stromatidium* Girty.

OCCURRENCE: Permian of west Texas.

GENUS **STROMATIDIUM** GIRTY, 1909

Stromatidium GIRTY, 1909, p. 77.

DIAGNOSIS: Sponge hemispherical or cylindrical, with narrow cloaca; each spicule layer is convex upward, and the layers are superposed in vertical series.

DISCUSSION: The basic structure of the skeleton is considered to be of familial significance. The presumed shape of the sponge is here cited tentatively as a generic character. The strong curvature of all the fragments suggests that the whole sponge was either a squat cylinder with a strongly arched upper surface, or was very nearly hemispherical. Only one fragment shows a narrow canal in the axial region, and the writer has interpreted this as a cloaca. The possibility that this was a parietal gap, in the center of a mammillate swelling on the side of a large vasiform sponge, cannot be discounted, but it does not seem likely.

GENOTYPE: *Stromatidium typicale* Girty, 1909. This is the only species.

Stromatidium typicale Girty, 1909

Plate 44, figures 7–9; text figure 77

Stromatidium typicale GIRTY, 1909, p. 77, pl. 27, figs. 7, 8, 8a, 9 (not figs. 10, 10a).

DIAGNOSIS: Dichotomous non-rectangular branching of tangential rays producing a non-quadrate mesh; distal surface of each tangential ray and the whole proximal ray delicately spinose, the spines sometimes bifurcate; proximal ray may bifurcate once terminally.

DESCRIPTION: The two most complete fragments (pl. 44, figs. 7–9) are of roughly circular outline, 5–7 mm. in diameter. The superposed spicule layers of which they are composed are concentric and strongly convex. In one specimen (pl. 44, fig. 7) the layers are relatively flat in the central region and sharply down-turned about the periphery; they are of approximately equal diameter. In the other specimen (pl. 44, figs. 8, 9) the layers are more or less hemispherical and decrease in diameter inward. The structure of the former is compatible with a cylindrical shape for the whole sponge. The structure of the latter, however, would seem to limit the probable shape of the whole sponge to something close to a portion of a sphere, unless each layer originally continued downward in the form of a cylinder. The second specimen contains a circular canal in the axial region, which may have been an excurrent opening or cloaca; it decreases in diameter from 1.0 mm. on the convex upper surface to 0.5 mm. on the broken lower surface, 4 mm. away. The superposed spicule layers are 0.5–1.0 mm. apart. Each layer is composed of pentacts, the intricately branched tangential rays of which form a continuous net with polygonal mesh spaces 0.05–0.40 mm. in diameter. The proximal ray of each pentact extends downward to, or nearly to, the upper surface of the underlying layer; there does not seem to be any significant fusion at the points of contact and, where present, is probably the result of diagenetic processes. The lower end of the proximal rays frequently branch into two rays, 0.1–0.4 mm. long, at variable angles to one another. The similar, but repeated, bifurcations of the tangential rays are commonly at close to a 45-degree angle from the parent ray, so that adjacent rays of three successive branchings from the same spicule outline a hexagonal mesh space (see text fig. 77). Branching probably does not proceed beyond the third bifurcation from the primary ray because of impingement against neighboring spicules. Some of the more irregular mesh spaces may be accounted for by the development of secondary synapticulae or by a nonparallel orientation of the basic pentacts. The upper surfaces of the tangential rays, including their branches, are covered with closely set, slender, vertically directed spines; they are about 0.1 mm. long and 0.2–0.3 mm. apart. Some of the spines bifurcate at the tip. The proximal rays bear similar projections on all sides, but they are more widely spaced and

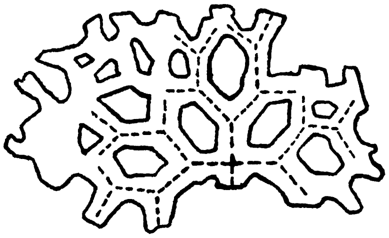

FIG. 77. *Stromatidium typicale* Girty, 1909. Camera lucida drawing of fragment of horizontal spicule layer; the fused branches of a single pentact are indicated by dashed lines; the center of the spicule is shown by a solid cross.

somewhat shorter. The under surfaces of the tangential rays are smooth and free of spines.

DISCUSSION: The tendency towards bifurcate branching, which gives rise to the intricate meshwork of the spicule layers, is evident throughout the whole skeleton of this sponge, down to the tips of the tiniest spines. The spinosity of the spicules and the nonrectangular nature of the branching are here cited as specific characters, but in a monobasic genus such evaluations are necessarily speculative. Girty noted the presence of loose, small, curved oxeas and hexacts associated with his specimens of this species, including one hexact entangled in the spicular net. He suggested that these spicules (Girty, 1909, pl. 27, figs. 10, 10a) may have been flesh spicules of *Stromatidium*. Inasmuch as similar spicules are common in the matrix at most of the localities of the present collections from which lyssacines have been recovered and are also integral parts of the skeleton of at least the docodermatids, there is no convincing reason for assuming that these belong to *Stromatidium* rather than to some other sponge.

This species is confined to the dark limestones of the Guadalupian series in the Guadalupe Mountains. The type locality, U.S.G.S. 2969 green, is probably the Pinery member of the Bell Canyon formation. A.M.N.H. 403 is the Rader member of the same formation, and A.M.N.H. 547 is the Getaway member of the Cherry Canyon formation. All are of basin lithology with admixtures of patch-reef faunal elements.

MATERIAL: Two fragments from A.M.N.H. 403, one from A.M.N.H. 547, and six fragments in Girty's type lot, from U.S.G.S. 2969 green, were available for study. All are silicified and were prepared with acid. In addition there are five slides of loose spicules mounted in balsam, in Girty's type lot, which the present writer does not consider to belong to the species.

OCCURRENCE: *Horizon:* Guadalupian. *Localities:* U.S.G.S. 2969 green; A.M.N.H. 403, 548 (Guadalupe Mountains). *Biotopes:* Basin facies; mixed basin and patch-reef facies. *Lithotope*: Dark limestones.

TYPES: Girty designated all the specimens of his type lot, except the slides of loose spicules, as cotypes, illustrating three of them. Unfortunately, the one illustrated on Girty's plate 27, figure 7, which was the most complete, is apparently lost. The present writer therefore here designates the specimen shown in Girty's figure 8 of his plate 27, U.S.N.M. No. 118134a, as lectotype. The remaining five fragments in Girty's type lot, U.S.N.M. Nos. 118134b–118134f, are paratypes. The hypotypes illustrated in the present paper are A.M.N.H. Nos. 28080 and 28080:1.

?BRACHIOSPONGIOIDEA, *INCERTAE SEDIS*

LYSSACINE, SPECIES 3

Plate 36, figures 12, 13

DESCRIPTION: Originally perhaps a globular or vasiform body, this fragmental specimen is now about half of an elliptical disc of which the greatest diameter is 30 mm. and the greatest thickness is 5 mm. Only the dermal layer of pentacts has been preserved, the interior being altogether hollow. Neighboring spicules are approximately parallel to one another but are arranged over all in obscurely concentric rows more or less parallel to the preserved edge of the disc. In many places three orders of size of spicules can be recognized, each about one-half of the size of the next larger spicule. The smaller spicules are generally external to the larger and were perhaps formed in order of decreasing size. The spicule rays are smooth and rather stout, with a strong taper. The dermal rays are of subequal length, the proximal ray is noticeably longer, and the aborted distal ray is almost always present as a short conical knob. The largest spicules are about 5 mm. across from tip to tip of the dermal rays, and individual rays are about 0.4 mm. thick. Those of the next smaller order of size measure 2 mm. across and 0.2–0.3 mm. in ray thickness. The smallest spicules are 1 mm. across and about 0.1 mm. in ray thickness. There is no trace of any other spiculation either in the dermal layer or in the interior, nor is there any evidence of osculum or root tuft.

DISCUSSION: The hollow discoidal shape resembles that of *Polylophidium discus*, new species, but the spicules of the present form are larger and stouter, and there is no indication of radiating bundles of monaxons such as characterize that species and the teganiids in general. The stoutness of the spicule rays and their strong taper, as well as the prominent knob formed by the aborted distal ray, suggest a possible affinity with the Brachiospongioidea. A more precise assignment must await better material.

MATERIAL: One silicified fragment prepared with acid; U.S.N.M. No. 127653.

OCCURRENCE: U.S.N.M. 703c, Word limestone number 1.

EUPLECTELLOIDEA FINKS,
NEW SUPERFAMILY

DIAGNOSIS: Hexasterophora with main skeleton a continuous, non-cubic mesh of hexacts, joined by fusion at points of mutual contact and by synapticulae.

INCLUDED FAMILIES: Euplectellidae (Cretaceous to Recent); Pileolitidae (Permian).

DISCUSSION: The two families included in this category differ from other hexactinellids in having a completely, or almost completely, rigid skeleton of non-dictyonine type. Possibly this non-cubic type of continuously fused skeleton, as well as the presence of connecting rods of secondary silica, or synapticulae, arose independently in the two families. However, there is some indication that both families may have had a common origin in the superfamily Brachiospongioidea or in a separate stock closely related to that complex. As do the brachiospongioids, the present families have a predominantly non-parallel arrangement of spicules and have well-developed parietal gaps. Furthermore, the distal rays of the dermalia in *Pileolites* are reduced to spherical knobs similar to those in many brachiospongioids, especially *Stioderma*. Also the peculiar T-shaped triacts characteristic of the brachiospongioid family Docodermatidae are found in many genera of the Euplectellidae, such as *Holascus*, *Taegeria*, and *Euplectella* itself. It should be noted, however, that similar triacts occur in *Hyalonema*, which is an amphidiscophoran and quite unrelated to the euplectellids.

PILEOLITIDAE FINKS, NEW FAMILY

DIAGNOSIS: Main skeleton built of parallel layers of randomly oriented, slender-rayed hexacts and reduced derivatives of hexacts, firmly united into a continuous net by synapticulae and by lateral fusion of spicule rays; tangential layer of specialized dermal spicules similarly fused; free diacts also present.

INCLUDED GENERA: *Pileolites* (Permian).

OCCURRENCE: Permian, Texas.

DISCUSSION: The structure of the species *Pileolites baccatus* is so different from that of any other hexactinellid that establishment of a separate family for it seems warranted. The skeleton is fused into a continuous, rigid, three-dimensional network, like that of the Mesozoic and later dictyonines. Unlike that of the dictyonines, however, this mesh is not cubic but consists rather of randomly oriented spicules organized into parallel layers, the whole being fused together by deposits of silica at points where spicule rays overlap or abut against one another. In addition to this fusion at points of contact, there are short bridges of secondary silica, called synapticulae, which connect neighboring, subparallel spicule rays.

This type of continuously fused but non-cubic skeleton is found in the still-living lyssacine family Euplectellidae, even to the presence of the ladder-like series of synapticulae. However, *Pileolites* differs in several major aspects: it has a massive form; it has a dense, three-dimensional skeletal net organized in parallel layers; and it has a tangent surface layer of specialized spicules oriented at right angles to the main skeleton but firmly fused to it. The euplectellids, on the other hand, are tubular; their skeleton is thin and essentially single-layered; and the surface spicules are not markedly differentiated from those of the main skeleton. These differences are of the same order as those generally used to separate families among the Hexactinellida.

PILEOLITES FINKS, NEW GENUS

DIAGNOSIS: Layers of main skeleton parallel to base of sponge and pierced by circular vertical canals which open only on upper surface; long, stout oxeas, unattached to main skeleton, oriented vertically in these canals; a single layer of dermal spicules covering the base and sides of the sponge, their rays tangential to the surface; distal ray of dermal hexacts reduced to a spherical knob.

OCCURRENCE: Leonardian (Wolfcampian?), west Texas.

DISCUSSION: It is difficult to determine, in a monobasic genus, precisely which characters should be considered specific and which generic. In the present genus, the shape and size of the sponge are treated here as specific characters, while the orientation of the skeletal layers, the configuration of the canal system, the form of the free diacts, and the shape of the dermalia are considered generic characters. Future discoveries of related forms may, of course, force a different evaluation.

GENOTYPE: *Pileolites baccatus*, new species.

Pileolites baccatus Finks, new species

Plate 19, figures 8–10; plate 50, figures 1–13

DIAGNOSIS: Sponge small, with flat base and with prismatic or subprismatic, vertical, or upwardly diverging sides; shape of whole sponge ranging from a flat cake to an inverted truncated cone or pyramid; exterior covered by the closely spaced spherical knobs of the dermal spicules.

DESCRIPTION: The individuals of this species are very small, their maximum dimensions ranging from 10 mm. to 29 mm. Their form is characteristic but of variable proportions. The base is flat or gently convex, the sides are perpendicular or upwardly divergent, and the top is shallowly concave, meeting the sides in a sharp, raised rim. The sponge may be much broader than high, so that it resembles a very flat cake, or it may be tall and narrow, much like a Turkish fez or a thimble, or it may be intermediate between these extremes. Commonly the sponge is elongate horizontally, which gives the tall, narrow individuals the form of a wedge. The sides are more or less prismatic, with five to eight flattish or concave faces of unequal width, which meet at sharp or rounded corners. The upper rim of the sponge is frequently higher at the angles between the faces of the sides. One of the long sides is usually higher than the other, and the sponge may be convex on this side and concave on the opposite side, somewhat like a horn coral. The sides commonly bear horizontal ridges and depressions at irregular intervals, probably representing successive positions of the upper rim. There is no root tuft.

The dermal layer covers the base and sides of the sponge; its elements are heavier (up to 0.13 mm. thick) and more firmly fused than those of the interior skeleton. The dermal hexacts are tangent to the surface but are not generally parallel to one another. Their tangential rays are almost certainly longer than the other rays, but because of their mutual fusion the length cannot be ascertained. Parallel adjacent rays, as can be seen in a few instances, are surrounded by a common envelope of secondary silica, which may account for as much as half of the diameter of the resulting fiber, but in most cases ray tips probably abut against the sides of adjacent rays to which they are welded; synapticulae are probably present but cannot be demonstrated as easily as in the interior net. The spherical knobs of the dermalia are 0.10–0.20 mm. (mostly 0.15 mm.) in diameter and 0.2–0.4 mm. apart, center to center. The approximately circular skeletal pores between them are 0.02–0.20 mm. in diameter; the larger are of about the same diameter and spacing as the intervening knobs.

The horizontal layers of the interior skeleton are 0.08–0.20 mm. apart. The horizontal elements are 0.02–0.05 mm. thick and as much as 4 mm. long. Within each layer these elements cross one another at random angles, though ladder-like configurations of two subparallel long elements, connected by synapticulae, are common. The synapticulae have the same diameter as the other horizontal elements and are spaced at intervals of 0.05–0.18 mm. Some of the crossings within a layer are rectangular and presumably represent the centers of individual spicules. The layers are connected by vertical elements of the same size and spacing as the horizontal synapticulae. Some of them are probably synapticulae, while others, which arise from horizontal crossings, are probably primary spicule rays. Near the junction between the horizontal layers and the tangent dermal layer covering the sides, the net is less regular. The mesh spaces of the interior net are rounded by the depositon of secondary silica; their diameters range from 0.025 mm. to 0.20 mm. The range within a single individual is less, however, some being finer meshed than others. The larger spaces are more clearly circular in section and represent more or less continuous horizontal or vertical canals. In addition to these openings there are large vertical canals which extend the full height of the sponge and open on the upper surface; they are 0.13–

0.50 mm. in diameter (mostly 0.25 mm.) and are 0.26–0.80 mm. apart. Usually they are closed at the basal end by the dermal layer, though in four flat specimens the basal layer is weakly developed, and the canals also open there. These canals were probably excurrent passages, though they may be homologous to parietal gaps of other hexactinellids.

Within the interior net, but not strongly fused to it, are numerous large fusiform oxeas, oriented vertically in the mesh spaces. The largest ones are located in the large vertical canals. Frequently the smaller ones occur in bundles of two or three. Some of the large ones extend for the whole height of the sponge and are broken off at each end so that their axial canals are exposed. The oxeas are 0.025–0.15 mm. thick, and the longest measured, which was broken at the end, was 4.2 mm. long. Some specimens also have short, fat, slightly curved oxeas loosely attached to the horizontal elements of the net, about 0.05 mm. thick and 0.40 mm. long; these may, however, be foreign spicules introduced post mortem.

BIOLOGICAL OBSERVATIONS: This sponge probably began its growth by expanding laterally as a very flat sheet, its limits determined by the space available as well as by internal biological factors. The remainder of its growth was then chiefly vertical, by the addition of successive horizontal layers of spicules bounded by the tangential dermal layer of the sides. The exigencies of available space may account for much of the great variability of form shown by this species. Most of the specimens are from U.S.N.M. 707ha, where they were extracted from a small piece of rock; consequently they must all have lived under very similar conditions. The bottoms at both localities, to judge from the enclosing rock, were crowded with loose spicules and shells. At both localities a few individuals incorporated a bit of this bioclastic material in the base. At U.S.N.M. 707ha the bottom may have been relatively soft lime-mud in spite of the quantity of shell debris. This is suggested by the preponderance of broad, flat individuals the shape of which may have been an adaptation to reduce sinking into the mud by a wide distribution of weight. The tall, narrow, slightly curved individuals, also found here, may have had their form determined by relatively rapid upgrowth to keep pace with sinking into the mud. At P.U. 80c the bottom may have been somewhat firmer. The specimens are more or less equidimensional. The base of one of them appears to have been molded to the interior of an adjacent shell from which it later came free. That these sponges were somewhat unstable is suggested by the fact that three of the specimens at P.U. 80c are now oriented upside down (see pl. 19, fig. 9), presumably having been overturned accidentally.

MATERIAL: From U.S.N.M. 707ha: about 30 complete or nearly complete specimens plus numerous small fragments; from P.U. 80c: 15 complete or partially complete specimens. All are silicified and were prepared with hydrochloric acid.

OCCURRENCE: *Horizon*: Basal Leonardian (U.S.N.M. 707ha may be Wolfcampian). *Localities*: Glass Mountains: U.S.N.M. 707ha; Sierra Diablo: P.U. 80c. *Biotope*: Basin facies. *Lithotope*: Strongly spiculiferous, somewhat bituminous limestone (that at U.S.N.M. 707ha is slabby, and the fossils are coated with limonite).

TYPES: Holotype, U.S.N.M. No. 127667 (U.S.N.M. 707ha); paratypes, U.S.N.M. Nos. 127668a–127668m (U.S.N.M. 707ha); P.U. Nos. 78863, 78862 (block with other sponges).

LYSSAKIDA, *INCERTAE SEDIS*

The spicules described below were obtained from the insoluble residues of limestones of basin facies or mixed basin and patch-reef facies. They are probably from lyssacine sponges but cannot be referred to any of the species described in this paper. Other isolated spicules, such as docodermatid triacts and dermal spicules of *Stioderma*, are discussed and the localities are given, under their respective categories. In addition to the spicules described below, there are many beds of the basin facies (for example, in the Bone Spring limestone, Word limestone number 1, and the limestone at U.S.N.M. 707ha) which consist almost entirely of oxeas and other spicule fragments (see pl. 33, fig. 8). Many of the spicules in these spiculite beds probably come from lyssacine hexactinellids, but the possibility that some are from monactinellid demosponges cannot be ruled out.

OXEAS, STRAIGHT: Smooth and more or less straight oxeas, 0.4–10.0 mm. long and 0.05–1.0 mm. in diameter, are known from the following localities: A.M.N.H. 46, 390, 480, 512; P.U. 1 L, 20g, 80c; U.S.G.S. 2915 green, 2953 green, 2970 green, 6674, 6692, 8561; U.S.N.M. 703c, 707ha; D.W.B. 188–6. It is possible that some of these are from monactinellid demosponges.

OXEAS, CURVED: Smooth, curved oxeas (pl. 33, fig. 9, three spicules at right) 0.5–5.0 mm. long are known from: A.M.N.H. 369, 480, 512, 547; U.S.G.S. 2969 green; U.S.N.M. 703c. At U.S.N.M. 703c there are larger oxeas (pl. 46, fig. 1) that may be as much as 40 mm. long and 2.0 mm. thick; they occur with similar ones (pl. 46, fig. 2) that are spinose at one end. These large forms are discussed under *Acanthocoryna stauroma*.

STYLES: At U.S.N.M. 703c there occur stout, curved, minutely spinose styles (pl. 33, fig. 9, three spicules at left) up to 2.0 mm. in length (the spines are not visible on the figure). Non-spinose, somewhat straighter styles of similar size also occur at this locality. Non-spinose, curved styles have been found at U.S.G.S. 2969 green (see Girty, 1909, pl. 27, fig. 10, upper left quadrant).

STRONGYLES: Smooth, strongly curved, stout strongyles, up to 0.4 mm. long and 0.15 mm. thick, have been found at U.S.N.M. 702 and 703c and U.S.G.S. 2969 green. The shorter strongyles frequently are as thick as the longer ones, so that their shape is somewhat like that of a bean or kidney. Similar spicules line a small depression on the base of *Dactylites micropora*, new species, at P.U. 80c; they do not seem to belong to that sponge (see pl. 24, fig. 5). Smaller but similar curved strongyles, including bean-shaped ones, were found adherent to specimens of several of the dictyosponge species in the Mississippian beds at Crawfordsville, Indiana, by Hall and Clarke (1899, p. 33, fig. 7, p. 175, fig. 30). Hinde (1888a, pl. 9, figs. 12d, e) illustrates even stouter bean-shaped spicules, which he referred to a new species of the demosponge *Geodites* Carter, 1871, a genus known only from isolated spicules, chiefly triaenes resembling those of the modern *Geodia* Lamarck. Although it is not possible to prove that these strongyles are not from demosponges rather than hexactinellids, their association with hexactinellid faunules in the Texas Permian, as well as their intimate connection with Mississippian dictyosponges, suggests that they are of hexactinellid origin.

FURCULAS: The term "furcula" is introduced here for some peculiar wishbone-shaped spicules from U.S.N.M. 703c (pl. 33, fig. 10, two spicules at right). The spicules are bilaterally symmetrical, consisting of two long, outwardly curving clads that meet in the midline at one end; from this point of juncture a very short third clad, frequently a mere knob, projects in the opposite direction. The whole spicule is gently curved in the sagittal plane. The total length is 1.0–2.0 mm. They somewhat resemble the cladomes of the anchor-shaped diaenes of "Lyssacine, species 1" with which they occur. The spicules appear to be complete, however, and differ from the diaenes not only in the lack of a rhabdome but also in the sagittal curvature and in the presence of the third, knob-like ray. To the writer's knowledge, nothing like these forms has been described in the literature.

DICHOTETRAENE: At P.U. 80c there was found a single specimen of what appears to be the cladome of a larger spicule (pl. 19, fig. 11). It measures about 0.8 mm. across and consists of four stout clads, which arise from the center at right angles to one another, and each of which almost immediately branches into two long, tapering, slightly recurved clads. The surfaces of the clads bear closely spaced annular ridges. One of the primary clads is broken off at the base, so that the two branches are missing. This fragment somewhat resembles a phyllotriaene, such as forms the dermal spiculation of tetracladine lithistids of the family Discodermiidae (for example, in *Ragadinia* Zittel). The primary branching of phyllotriaenes, however, is tripartite, whereas in the present example it seems to be quadripartite and at right angles. For this reason, the spicule is interpreted as a hexactinellid tetraene. The ornamentation of annular ridges is unusual; to some extent it resembles the ornamentation seen on the hexacts of *Spiractinella* Hinde, 1888a.

OXYHEXASTERS: The forms described under this name (pl. 33, fig. 6) resemble some of the oxyhexaster microscleres of hexasterophoran hexactinellids but are larger than usual, measuring 0.4–0.7 mm. across. They consist of six equally developed rays, each of which bears four diverging branches at its terminus. These branches are directed at a 45-degree angle to the planes of the primary axes and make approximately the same angle with the axis of the parent ray. They occur at U.S.N.M. 703c and 707ha. Most are covered with closely set minute spines, but one at U.S.N.M. 703c was smooth. These spicules may represent microscleres of lyssacines; though they are larger than the corresponding spicules of modern lyssacines, they are considerably smaller than the principal spicules of most lyssacines in the present collections.

HEXACTS, SPINOSE: At P.U. 80c were found several stout, spinose hexacts (pl. 33, fig. 4), 0.8–1.0 mm. across and 0.08–0.10 mm. in ray thickness. They are coarser and more stubby-rayed than the spinose hexacts of *Stioderma coscinum*. They are more regularly spined than *Acanthactinella* Hinde, 1888a.

SIMPLE HEXACTS, PENTACTS, AND STAURACTS: Many of these probably belong to one or another of the lyssacine species described herein but in isolation cannot be referred to a particular one. They are listed here to provide a record of hexactinellid occurrences. Hexacts are known from: A.M.N.H. 46, 369, 480, 503, 505, 512, 519, 547, 666; D.W.B. 188–6; P.U. 1 L, 80c, 83t; U.S.G.S. 2943 green, 2959 green, 2969 green, 7175c green, 6674, 8561; U.S.N.M. 702, 702b, 703c, 705a, 707e, 707ha. Pentacts are known from: A.M.N.H. 503; P.U. 1 L, 3; U.S.G.S. 2915 green; U.S.N.M. 703c, 705a. Stauracts are known from: A.M.N.H. 503 and U.S.N.M. 703c.

REGISTER OF LOCALITIES

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21SW. Cherry Canyon formation, Getaway limestone member: Guadalupe Pass, vicinity of BM 5426, just south of road in gully.

46. Bone Spring formation, dark gray limestone approximately 300 feet above base: 1 mile northwest of the mouth of Apache Canyon, Sierra Diablo, Texas.

52. Hueco formation, basal upper: Hueco Mountains, approximately 100 yards west of BM 5318, 1½ miles north-northeast of Hueco Inn.

369. Bone Spring limestone: Top of Shirttail Canyon, above the drilling well (now abandoned), Humble Oil and Refining Co., E. P. Crowden A No. 14E, Pure Oil Co. (Rig No. 17), Guadalupe Mountains, Texas.

369a. Bone Spring limestone: Float blocks near A.M.N.H. 369.

381. Bone Spring limestone (lower part): 50 feet below top of knob on front of south side of Victorio Canyon, West Pyle cattle ranch, Sierra Diablo, Texas.

389. Bell Canyon formation, upper division of Rader limestone member: Flagstone quarries, approximately 0.5 mile south of Bell Canyon bridge on U. S. Highway 62; approximately 2 miles northeast of Nickel Creek Station, Guadalupe Mountains, Texas.

390. Hueco formation: 1.1 miles northeast of BM 5325, Rancheria Mountain, Hueco Mountains, El Paso and Hudspeth counties, Texas.

403. Bell Canyon formation, Rader limestone member: Hill crest immediately southeast of Hegler ranch house, Guadalupe Mountains, Texas.

480. Bone Spring limestone (upper part): Near Hunter tank, ½ mile south of Hill 5087, southern Guadalupe Mountains, Texas. Approximately the same as U.S.G.S. 2920 green.

500. Leonard formation: Same as U.S.N.M. 702.

501. Word formation, near top of limestone no. 1: Same as U.S.N.M. 703 but a different lens.

503. Word formation, near top of limestone no. 1: Same as U.S.N.M. 703c but a different lens.

505. Word formation, limestone no. 2: Same as U.S.N.M. 706c.

510. Leonard formation, Hess facies *Scacchinella* bed: At mouth of Hess canyon, about ¾ mile north of the Hess ranch house, Hess Canyon quadrangle, Texas.

512. Cherry Canyon formation, Getaway limestone member: Near break in slope on middle leader on west side of airway station road, between the highway and the pipeline road, on the crest of the ridge, Guadalupe Mountains, Texas. Same as U.S.N.M. 728.

519. Cherry Canyon formation, Getaway limestone member: On west slope of outlier due northeast of BM 5315 in right-angle bend in Highway 62, approximately 0.5 mile east of airway station, Guadalupe Mountains, Texas.

547. Cherry Canyon formation, Getaway limestone member: 1 mile due west of Anderson Prichard No. 1 border location, in Salt Basin, Guadalupe Mountains, Texas.

628. Bone Spring limestone, lower part: South side of the mouth of Victorio Canyon, Van Horn quadrangle, Texas.

629. Bone Spring limestone, 30 feet above massive bed at top of Hueco limestone: 0.25 mile south of the mouth of Victorio Canyon, Van Horn quadrangle, Texas.

666. Bone Spring limestone (float): From several parts of Pure-Hunter No. 1 oil well canyon.

675. Bone Spring limestone: Near base of Delaware Mountain escarpment at high promontory south of Hoag Canyon, southern Guadalupe Mountains, Texas.

DONALD W. BOYD COLLECTION

188-6. San Andres formation (lower part), transition facies between shelf and basin: North wall of Last Chance Canyon in SE. ¼, sect. 32, T. 23 S., R. 22 E., opposite mouth of Whiteoaks Canyon, Bandanna Point quadrangle, New Mexico. Approximately the same as U.S.N.M. 749.

1144. Cherry Canyon formation, sandstone tongue: SE. ¼, SE. ¼, sect. 12, T. 26 S., R. 19 E., El Paso Gap quadrangle, New Mexico.

1146. Cherry Canyon formation, sandstone tongue: NW. ¼ sect. 7, T. 26 S., R. 20 E., El Paso Gap quadrangle, New Mexico.

PRINCETON UNIVERSITY

1 L. Bone Spring limestone, sequence of dark limestone beds just below the Victorio Peak member: Northwest wall of Apache Canyon, near top of the double spur just west of the "C" in "Canyon," Van Horn quadrangle, Texas.

1r. Bone Spring limestone, dark limestone beds just above basinward edge of main Bone Spring reef: Northwest wall of Apache Canyon, on double spur just west of the "C" in "Canyon," Van Horn quadrangle, Texas.

1rc. Bone Spring limestone, dark limestone beds immediately above main Bone Spring reef and fore-reef talus: Northwest wall of Apache Canyon, on double spur just west of "C" in "Canyon," Van Horn quadrangle, Texas.

2. Bone Spring dark limestone (base): Northwest wall of Apache Canyon, just above base of slope at mouth of second side canyon south of the mouth of Apache Canyon, Van Horn quadrangle, Texas.

3. Bone Spring limestone, molluscan ledge about 100 feet above base: Northwest wall of Apache Canyon near mouth, just north of Van Horn quadrangle, Texas.

3e. Bone Spring limestone (just below molluscan ledge): Just east of P.U. 3, northwest wall of Apache Canyon near mouth, just north of Van Horn quadrangle, Texas.

10x. Bone Spring limestone, dark limestone beds, 100 to 200 feet above main Bone Spring reef: Northwest wall of Apache Canyon, on small side spur just southwest of double spur of P.U. 1r and 1rc (see above), Van Horn quadrangle, Texas.

10up. Bone Spring limestone: Approximately the same as P.U. 10x (see above).

16x. Bone Spring limestone, dark limestone beds in front of basinward margin of main Bone Spring reef: Southeast wall of Apache Canyon at approximately 5600-foot contour on spur opposite BM 6073, Van Horn quadrangle, Texas.

20f. Bone Spring formation, base of Victorio Peak limestone member: Northern end of ridge which forms the northwest wall of Apache Canyon, hill shown by closed 5600–foot contour at northern edge of Van Horn quadrangle, Texas.

20g. Bone Spring formation, base of Victorio Peak limestone member: Northwest wall of Apache Canyon at hill formed by closed 5650-foot contour at numerals "57" just below northern edge of Van Horn quadrangle, Texas.

20gh. Bone Spring formation, base of Victorio Peak limestone member: Northwest wall of Apache Canyon in saddle between locality 20g and Hill 5739 (locality 20h), Van Horn quadrangle, Texas.

20h. Bone Spring formation, base of Victorio Peak limestone member: Northwest wall of Apache Canyon at Hill 5739, Van Horn quadrangle, Texas.

20i. Bone Spring formation, base of Victorio Peak limestone member: Northwest wall of Apache Canyon, cliffs at northeast edge of plateau, between 5850-foot and 5950-foot contours, just east of numerals "6232" on Van Horn quadrangle, Texas.

29. Bone Spring formation, Victorio Peak limestone member: Top of Sierra Diablo plateau along road between 6400-foot and 6450-foot contours, 1 mile southwest of BM 6630, Van Horn quadrangle, Texas.

32. Bone Spring formation, Victorio Peak limestone member: On Sierra Diablo plateau at upper end of north branch of Mine Canyon, 0.3 mile north of BM 6630, Van Horn quadrangle, Texas.

48sd. Bone Spring formation: Canyon back of Cumming's Ranch at base of Sierra Diablo escarpment east of Victorio Peak, just east of "Pk" on Van Horn quadrangle, Texas.

53b. Hueco limestone, patch reef just below unconformity at base of Bone Spring formation: Northwest wall of Apache Canyon at elevation of approximately 4900 feet, on spur which starts at "C" in "Canyon" on Van Horn quadrangle, Texas.

53g. Bone Spring formation (base), talus tongue from farthest extension of main Bone Spring reef: Northwest wall of Apache Canyon, at elevation of approximately 5000 feet on spur just west of "C" in "Canyon" on Van Horn quadrangle, Texas.

54d. Bone Spring formation, Victorio Peak limestone member: At top of mountain 0.6 mile south of Apache Peak, Van Horn quadrangle, Texas.

60a. Hueco limestone: Finlay Mountains, about 2 miles northeast of Wilkey Ranch on the slope northwest of "F" in "Finlay" on Fort Hancock quadrangle, Texas.

70c. Bone Spring limestone, fore-reef talus below main Bone Spring reef: Northwest wall of Apache Canyon at elevation of approximately 5530 feet, just south of "0" in "BM 6073" on Van Horn quadrangle, Texas.

77. Bone Spring formation, base of Victorio Peak limestone member: In saddle south of mountain (locality 54d) which is 0.6 mile south of Apache Peak, Van Horn quadrangle, Texas.

80c. Bone Spring dark limestone, basal beds: Near top of northernmost hill on east side of Black John Canyon, Sierra Diablo, 2.9 miles west-northwest of BM 3585 at Figure Two Ranch, Van Horn quadrangle, Texas.

83t. Bone Spring dark limestone, above main Bone Spring reef: West wall of Black John Canyon, near top of shoulder at elevation of approximately 5000 feet, at point 1.2 miles due south of "e" in "Apache Pk" on Van Horn quadrangle, Texas.

84t. Bone Spring limestone, lower part: On east slope of mountain (locality 54d) 0.6 mile south of Apache Peak, at elevation of approximately 5000 feet, Van Horn quadrangle, Texas.

UNITED STATES GEOLOGICAL SURVEY

The upper Palezoic unit of the Paleontology and Stratigraphy Branch has two separate series of locality numbers. An earlier series of "green" numbers is no longer used, but a "blue" series has been used since the early 1900's. With the exception of the first 10 localities listed, all numbers refer to the blue catalogue.

2006 green. Wewoka formation, middle (25–75 feet below sandstone): Bluffs on north side of Canadian River valley, northern part of sect. 5, T. 6 N., R. 9 E., and adjacent southern part of sect. 32, T. 7 N., R. 9 E., Wewoka quadrangle, Oklahoma.

2520 green. Plattsburg ("Allen") limestone: Cut on the Santa Fe Railroad, 6 miles southwest of Chanute, Kansas.

2915 green. Hueco limestone (chiefly from upper one-third of brown limestone exposed): Spur south of Cerro Alto and south of road, this spur parallel to and just north of that of 2925 green, Hueco Mountains, Cerro Alto quadrangle, Texas.

2920 green. Bone Spring formation, near top of black limestone: Small canyon among foothills about 2 miles south-southeast of Guadalupe Peak, southern Guadalupe Mountains, Texas. This is approximately the same as A.M.N.H. 480.

2943 green. Hueco formation: Hill on east side of road on south side of Sparrow tanks, eastern Hueco Mountains, Cerro Alto quadrangle, Texas.

2953 green. Hueco formation: Mountain 2 miles southeast of BM 4162, Cerro Alto quadrangle, Texas.

2959 green. Hueco formation: Western part of Finlay Mountains, 2 miles southeast of Tenley Ranch and 7½ miles north of Finlay Station of Southern Pacific Railroad.

2969 green. Bell Canyon formation, probably Pinery limestone member: On east wall of canyon at the southern end of the Delaware Mountains, approximately 1 mile due north of BM 5073 and ½ mile due south of Hill 5107 on Van Horn quadrangle, Texas.

2970 green. Hueco formation: Extreme southeastern hills of Hueco Mountains, 8 miles southwest of Tepee Butte, Cerro Alto quadrangle, Texas.

7175c green. Probably Guadalupian basin facies limestone: Small canyon on west face of Delaware Mountains, approximately 1¼ miles northwest of BM 4925 on Van Horn quadrangle, Texas.

5713. Bone Spring formation, Victorio Peak limestone member: Top of Sierra Diablo plateau, 2 miles northeast of "Bond Ranch" (probably Bounds' Ranch), Van Horn quadrangle, Texas.

5777. Bone Spring limestone, approximately 700 feet below unconformity on top of black limestone: Mouth of Shirttail Canyon at 6000-foot contour, Guadalupe Mountains, Texas.

5874. Wolfcamp formation: Northwest of Wolf Camp, Glass Mountains, Texas. Udden's locality for Wolfcamp fossils.

6656. Leonard formation, near top: Lower half of west end of the mountain north of Leonard Mountain, below the massive limestone, Glass Mountains, Texas.

6660. Leonard formation, lower part: At Sullivan Peak, Glass Mountains, Texas.

6674. Probably Guadalupian limestone: At pipeline road at south end of crest of low ridges, 5 miles southwest of Guadalupe Point, Guadalupe Mountains, Texas.

6692. Leonard formation, one-third of the way up from base: 3 miles east-northeast of Sullivan Peak, along road, Glass Mountains, Texas.

6938. Bone Spring limestone: Plateau at top of west wall of Black John Canyon, 0.8 mile south of "e" in "Apache Pk" on Van Horn quadrangle, Texas.

7001a. Hueco limestone, basal marly beds: Base of Sierra Diablo escarpment at north side of mouth of Mine Canyon, 2 miles southwest of Figure Two ranch, Van Horn quadrangle, Texas.

7004. Hueco limestone, base: Approximately the same as U.S.G.S. 7001a.

7011. Bone Spring formation, Victorio Peak limestone member: Top of Sierra Diablo plateau, above upper cliffs at head of Marble Canyon, 0.6 mile south of BM 6630, Van Horn quadrangle, Texas.

7047. Wolfcamp formation, *Uddenites*-zone: West end of Wolf Camp Hills, ½ mile north of Wolf Camp, Glass Mountains, Texas.

7055a. Bone Spring limestone, above molluscan bed: Sierra Diablo plateau west of Black John Canyon, 2.3 miles south and 5.8 miles east of northwest corner of Van Horn quadrangle, Texas.

8543. Bone Spring limestone, lower part, limestone interbedded with "pebble beds": Sierra Diablo plateau west of Victorio Canyon, on south side and point of ridge 12.58 miles south and 4.3 miles east of northwest corner of Van Horn quadrangle, Texas.

8548. Cherry Canyon formation, Goat Seep limestone member: Top of cliffs at South Mesa, Sierra Diablo, Texas.

8561. Bone Spring limestone, dark limestone about 178 feet above base: At Victorio Peak, Van Horn quadrangle, Texas.

8562. Bone Spring limestone, basal reefy beds up to 63 feet above Hueco formation: At Victorio Peak, Van Horn quadrangle, Texas.

14429. Bone Spring limestone, lower part: Victorio Canyon, not far above channel, at junction with large canyon coming in from south, 1.6 miles east of Estes place, Van Horn quadrangle, Texas.

14444. Bone Spring formation, Victorio Peak limestone member: Crest of Sierra Diablo plateau above Marble Canyon, 4.3 miles south and 5.3 miles east of northwest corner of Van Horn quadrangle, Texas.

14454. Bone Spring limestone: South of Victorio Peak, 6.7 miles east and 14.0 miles south of northwest corner of Van Horn quadrangle, Texas.

14461. Bone Spring limestone: Northwest wall of Apache Canyon, 3.8 miles east and 0.6 mile south of northwest corner of Van Horn quadrangle, Texas.

14467. Bone Spring limestone: Northwest wall of Apache Canyon, 3.3 miles east and 1.1 miles south of northwest corner of Van Horn quadrangle, Texas.

14470. Bone Spring formation, Victorio Peak limestone member: Crest of Sierra Diablo plateau, 1 mile north of BM 6630, 5.5 miles east and 2.9 miles south of northwest corner of Van Horn quadrangle, Texas.

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510b. Keechi Creek formation: ¼–½ mile west, northwest and north of Union Hill School, 6 miles north-northwest of Mineral Wells, Texas.

510c. Palo Pinto limestone: Quarry of Mineral Wells Crushed Stone Company, 3 miles due north of Salesville on the Salesville–Oran road in the eastern half of the Moreau Forest Survey, and ¼ mile south of the railroad, Palo Pinto County, Texas.

518a. Millsap Lake formation, Dickerson shale member (shale below Kickapoo Falls limestone member): 1½ miles below Kickapoo Falls on scarp overlooking Kickapoo Valley, near Schultz ranch house.

518f. Graford formation, Brownwood shale member 35 to 55 feet below Rock Hill limestone: Road cut 0.9 mile north of Lake Bridgeport Dam, 0.1 mile west on pavement from turnoff to Bridgeport Lake, 4½ miles northwest of Bridgeport, Wise County, Texas.

518g. Graford formation, Rock Hill limestone member: 4 miles west-northwest of Bridgeport, Wise County, Texas.

518i. Ochelata group, unnamed shale 30 feet above Torpedo sandstone: NW. ¼, NW. ¼, sect. 10, T. 28 N., R. 13 E., Washington County, Oklahoma.

518j. Wann shale: Center of eastern half of sect. 25, T. 24 N., R. 12 E., Washington County, Oklahoma.

518k. Wann shale: Sect. 9, T. 28 N., R. 13 E., 2 miles north of Copan, Oklahoma.

518L. Pawnee limestone: West bluff of Verdigris River, SE. ¼, sect. 26, T. 26 N., R. 16 E., Nowata County, Oklahoma.

518m. Ochelata group, shale above Torpedo sandstone: "The Mound," southeast corner of sect. 3, T. 26 N., R. 12 E., ¼ mile north of U. S. Highway 60, at western edge of Bartlesville, Oklahoma.

518o. Stanton (?) formation, shale below limestone: 1.4 miles west of junction of Kansas Highway 96 and U. S. Highway 75, at western edge of Neodesha, Kansas.

518p. Stanton (?) limestone: 7.5 miles by road southeast of the junction of the Fredonia–Neodesha road and Kansas Highway 47, Wilson County, Kansas.

518q. Magdalena limestone (30–40 feet below top of formation): Ledge on north side of an arroyo just east of the Grapevine Canyon road, one-eighth of a mile south of Old Juniper and a cattle tank, about in the center of W. ½, SE. ¼, SW. ¼, sect. 25, T. 19 S., R. 11 E., Escondido Canyon (15′) quadrangle, Otero County, New Mexico.

700. Gaptank formation (middle of Bed 10 of P. B. King): 2 miles south, 17° east, of Gaptank, 1¼ miles east of a point on the Fort Stockton road 2 miles south of Gaptank, about 23½ miles northeast of Marathon, Texas.

700a. Gaptank formation (upper part of Bed 10 of P. B. King): 2 miles south, 17° east, of Gaptank, 1½ miles east of a point on Fort Stockton road 2 miles south of Gaptank, 23½ miles northeast of Marathon, Texas, but ¼ miles east in a small canyon.

701. Wolfcamp formation (upper 15 feet of bed 2): Bed of stream and both banks, and dip slope to southeast just northeast of small canyon about 0.4 mile upstream from mouth, Wolfcamp Hills, Hess Canyon quadrangle, Texas.

701a. Wolfcamp formation (upper part of bed 9): Head of canyon, just south of forks, Wolfcamp Hills, Hess Canyon quadrangle, Texas.

701a2. Wolfcamp formation (between beds 2 and 9): Slopes on south side of main canyon at forks, 0.4 mile north, 81° west, of Hill 5060, Wolfcamp Hills, Hess Canyon quadrangle, Texas.

701c. Wolfcamp formation (beds 9 to 12): Crest of hill forming north side of canyon, on west side of tributary arroyo 0.2 mile up canyon from entrance, Wolfcamp Hills, Hess Canyon quadrangle, Texas.

701d. Wolfcamp formation (beds 9 to 12): Two small hills 1 mile northwest of Wolfcamp, west end of Wolfcamp Hills, Hess Canyon quadrangle, Texas.

701h. Wolfcamp formation (beds 9 to 12) patch reef: Crest of hill, 0.75 mile south, 78° west, of Hill 5060, Wolfcamp Hills, Hess Canyon quadrangle, Texas.

701k. Wolfcamp formation (bed 12) patch reef: West side of hill 0.97 mile south, 82° west, of Hill 5060, at elevation of 4750 feet, west end of Wolfcamp Hills, Hess Canyon quadrangle, Texas.

701L. Wolfcamp formation (bed 2) patch reef: About 4625 feet in elevation on south side of hill, 0.87 mile south, 69° west, of Hill 5060, Wolfcamp Hills, Hess Canyon quadrangle, Texas.

701p. Wolfcamp formation, *Uddenites*-zone: West end of Wolfcamp Hills, Hess Canyon quadrangle, Texas.

701z. Wolfcamp formation, upper shale under third limestone (beds 13 to 14): On west side of canyon, just north of elbow, about ½ mile west of Hill 5060, Wolfcamp Hills, Hess Canyon quadrangle, Texas.

702. Leonard formation, upper part (original Leonard of P. B. King): Slopes on south side of road 0.2–0.5 mile east of Split Tank, 1½ miles northeast of road fork near old Word Ranch, about 19 miles north-northeast of Marathon, Hess Canyon quadrangle, Texas.

702b. Leonard formation, upper part (lower part of original Leonard of P. B. King): ½ mile east of Split Tank, 19 miles north-northeast of Marathon, Hess Canyon quadrangle, Texas.

702d. Leonard formation (Hess member, eastern facies): Crest of hills 3.8 miles (airline) north, 67° east, of Hess ranch house, 0.4 mile southwest of head of south branch of Hess Canyon, Hess Canyon quadrangle, Texas.

702e. Leonard formation, Hess limestone member: Point of hill about 5700 feet in elevation, 3.6 miles (airline) north, 67° east, of Hess ranch house, Hess Canyon quadrangle, Texas.

702h. Wolfcamp formation, shale just above bed 12: Center of Wolfcamp Hills, Hess Canyon quadrangle, Texas.

703. Word formation, limestone no. 1: Lens with goniatites in platy limestone near top of slope, ½ mile southwest of road fork just northeast of old Word Ranch, Hess Canyon quadrangle, Texas.

703a. Leonard formation, uppermost part (*Aulosteges* bed): On northwest side of road between road fork and sheep tank near old Word Ranch, about 17 to 18 miles north-northeast of Marathon, Hess Canyon quadrangle, Texas.

703b. Leonard formation, upper part (lower part of original Leonard of P. B. King): On southeast side of road between road fork and sheep tank at old Word Ranch, Hess Canyon quadrangle, Texas.

703c. Word formation, limestone no. 1: Crest of slope ¼–½ mile southwest of road fork near old Word Ranch, 17 to 18 miles northeast of Marathon, Hess Canyon quadrangle, Texas. Sponge bed. Basal portion dark platy limestone called Word no. 1 by King, just above reefy beds on crest of slope on north side of road, ¼ mile southwest of road fork near old Word Ranch.

703e. Word formation, limestone no. 2: About 1.4 miles west-southwest of Split Tank, Hess Canyon quadrangle, Texas.

705a. Leonard formation, Hess limestone member: 0.7 mile (airline) north, 13° west, of the Hess ranch house, Hess Canyon quadrangle, Texas.

705k. Wolfcamp formation, Hess member, western facies, *Scacchinella* bed: At elevation of approximately 5400 feet on Leonard Mountain, Hess Canyon quadrangle, Texas.

705v. Wolfcamp formation, *Uddenites*-zone: Uppermost shale at elevation of 5150 feet on southern slope of Leonard Mountain, due south of BM 5860, Hess Canyon quadrangle, Texas.

706. Word formation, lower part of limestone no. 3: North slope of hill on south side of Hess Canyon, 4 miles north, 35° east, of Hess Ranch, 14 miles north-northeast of Marathon, Hess Canyon quadrangle, Texas.

706c. Word formation, about middle of limestone no. 2: Southwest slope and crest of low hill 3.7 miles (airline) north, 36° east, of Hess ranch house, Hess Canyon quadrangle, Texas.

706e. Word formation, top of limestone no. 3: East side of small arroyo 4.1 miles (airline) north, 34° east, of Hess ranch house, Hess Canyon quadrangle, Texas.

706g. Wolfcamp formation, 20 feet above conglomerate: ½ mile north of Hess ranch house, Hess Canyon quadrangle, Texas.

706x. Wolfcamp formation (bed 12 to top): Just west of canyon just above sharp elbow, 0.5 mile north, 76° west, of Hill 5060, Wolfcamp Hills, Hess Canyon quadrangle, Texas.

707b. Leonard formation, top of limestone no. 1: North side of arroyo 4.1 miles (airline) due north of Decie ranch house, 1 mile northwest of entrance to Sullivan Ranch Canyon, Altuda quadrangle, Texas.

707e. Word formation, limestone no. 1: 5.3 miles (airline) north, 5° west, of Decie ranch house, 0.9 mile (airline) south, 25° east, of Sullivan Peak, on nose of foothill southeast of Sullivan Peak, Altuda quadrangle, Texas.

707f. Leonard formation, limestones nos. 3 and 4: 4.2 miles (airline) north of Decie ranch house in hill 2.3 miles (airline) south, 17° east, of Sullivan ranch house, Altuda quadrangle, Texas.

707ha. Leonard formation, lower part, or Wolfcamp formation, upper part (Productid bed, above bed with beaded leptodid): Small knob ½ mile southeast of Hill 5300, 2.7 miles (airline) north, 12° west, of Decie ranch house, Altuda quadrangle, Texas.

707j. Wolfcamp formation, 20 to 30 feet above base (*Artinskia* bed): At elevation of 4560 feet on nose of hill 1 mile east of Hill 4902, northwest of Decie Ranch, Altuda quadrangle, Texas.

707m. Wolfcamp formation, top 10 feet of conglomerate: About 95 feet vertically below Hess at 4650-foot contour in ravine ½ mile southeast of Hill 5300, north of Decie Ranch, Altuda quadrangle, Texas.

707o. Wolfcamp formation, lower 30 feet of upper shale below Hess limestone member of Leonard formation: 100 yards south, 81° east, of Hill 4902, 3 miles north of Decie Ranch, 1.3 miles southwest of Hill 5300, Altuda quadrangle, Texas.

707q. Leonard formation: Base of hill just east of Clay Slide, Altuda quadrangle, Texas.

709. Leonard formation, upper part (original Leonard of P. B. King): Small knob and saddle on north side of Leonard Mountain, 2 miles (airline) south, 80° west, of Hess Ranch, Hess Canyon quadrangle, Texas.

712e. Hueco limestone: Hueco Mountains, Texas. Same as A.M.N.H. 52.

715. Wolfcamp formation, goniatite bed, 30 feet below Hess limestone member of Leonard formation: Under high point (5195 feet) of Dugout Mountain, Monument Springs quadrangle, Texas.

715d. Wolfcamp formation (bed 14): Northeast slope of hill 0.7 mile due west of Hill 5060, Wolfcamp Hills, Hess Canyon quadrangle, Texas.

728. Cherry Canyon formation, Getaway limestone member: Same as A.M.N.H. 512.

749. San Andres formation, limestone ledge above calcareous siltstones about 400 feet below Queen sandstone: Last Chance Canyon, SE. ¼, sect. 32, T. 23 S., R. 22 E., Bandanna Point quadrangle, New Mexico. Approximately the same as D.W.B. 188-6.

806n. Monos formation, *Anidanthus* zone: East slope of largest hill (295 meters) south of Mill Hill, 2 miles northeast of El Antimonio, northwestern Sonora, Mexico.

3302. Magdalena formation, limestone 30 feet to 50 feet below base of Abo red beds: ¼ mile south of Old Juniper, along the road, center of south line of SW. ¼, sect. 25, T. 19 S., R. 11 E., upper Grapevine Canyon, Otero County, Sacramento Mountains, New Mexico.

3305. Magdalena formation, 30 feet to 40 feet below top: ⅛ mile south of Old Juniper, from small draw where it crosses the road, center of eastern half of SW. ¼, sect. 25, T. 19 S., R. 11 E., upper Grapevine Canyon, Otero County, Sacramento Mountains, New Mexico. From 5 feet above U.S.N.M. 3302.

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25. Sponge-bearing limestone, probably bed 15 of Difunta section: 400 meters south, 35° east, of La Difunta, near Las Delicias, southwestern Coahuila, Mexico.

37. Leonard formation: Tank west of north end of Iron Mountain, Glass Mountains, Texas.

46. Word formation, limestone no. 1: South face of Sullivan Peak, Glass Mountains, Texas.

87. Wolfcamp formation (bed 12): 1 mile west by north of Wolfcamp, Hess Canyon quadrangle, Texas.
88. Wolfcamp formation, *Uddenites*-zone: At Wolfcamp, Hess Canyon quadrangle, Texas.
89. Wolfcamp formation, bed 4: At Wolfcamp, Hess Canyon quadrangle, Texas.
92. Wolfcamp formation, bed 14: At Wolfcamp, Hess Canyon quadrangle, Texas.
93. Wolfcamp formation, bed 9 and above: On side of arroyo northeast of Wolfcamp, Hess Canyon quadrangle, Texas.
95. Wolfcamp formation, *Uddenites*-zone: At Hill 4752, northeast of Wolfcamp, Hess Canyon quadrangle, Texas.
168. Wolfcamp formation, gray limestone member: At Wolfcamp, Hess Canyon quadrangle, Texas.
175. Wolfcamp formation, below gray limestone member: Northeast of Wolfcamp, Hess Canyon quadrangle, Texas.
192. Word formation, limestone no. 4: North of junction of Road and Gilliland canyons, Glass Mountains, Texas.
198. Wolfcamp formation: Upper fossiliferous bed in the graben near the middle of the Hess Ranch horst, and the same bed to the west of the graben, Hess Canyon quadrangle, Texas.
222. Leonard formation, Hess limestone member, *Perrinites*-bed: On scarp east of head of east fork of Hess Canyon, about 0.25 mile below and southeast of Hill 5767, Hess Canyon quadrangle, Texas.
478. Bone Spring formation, lower part below dark limestones ("Hess" formation of R. E. King), lower two fossiliferous layers in upper part of this unit: 1.5 miles east of BM 6140, south of Victorio Peak, Van Horn quadrangle, Texas.
502. Leonard formation (Bone Spring formation), beds 5 to 6, mostly bed 5, of Baylor Mountains section of R. E. King: Baylor Mountains, Van Horn quadrangle, Texas.

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vokesi, Heliospongia, 48

wanneri, Hindia, 98
Wewokella, 17, 23, 26, 27, 36, 50, 52, 117
  solida, 18
  ("*Talpaspongia*"), 27
Wyoming, 72

Zittelella, 59

PLATES 1–50

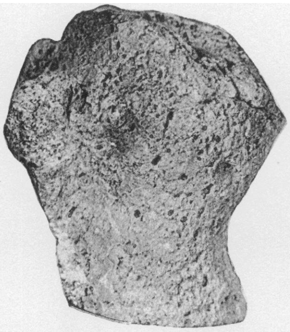
PLATE 1

1, 2. *Heliospongia* cf. *excavata* Girty. 1. Side of top end of branch, U.S.N.M. No. 127584, from U.S.N.M. 700, Gaptank formation. 2. Top of same specimen showing terminal oscule.

3–6. *Heliospongia excavata* King. 3. Reduced side view of very large, nearly complete individual, showing flabellate, anastomosing branches with numerous oscules, U.S.N.M. No. 127581, from U.S.N.M. 518g, Rock Hill limestone. 4. Cylindrical branches, topotype, U.S.N.M. No. 127582a, from U.S.N.M. 518f, Graford formation. 5. Side of flabellate branch, showing stellate grooves about ostia, U.S.N.M. No. 127580a, from U.S.N.M. 518g, Rock Hill limestone. 6. Flabellate branch showing apopores in cloacas at right, topotype, U.S.N.M. No. 127582b, from U.S.N.M. 518f, Graford formation.

7. *Heliospongia vokesi* King. Top of branch, U.S.N.M. No. 127588b, from U.S.N.M. 702d, Leonard formation.

All figures are natural size except 3, which is approximately three-tenths natural size.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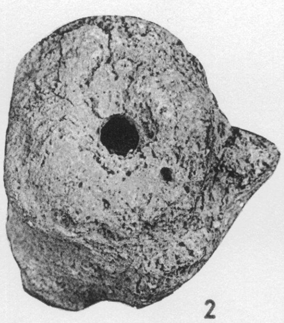
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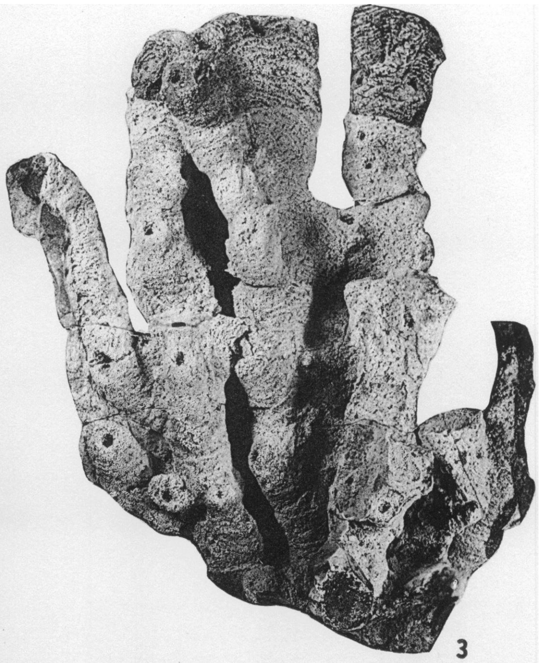
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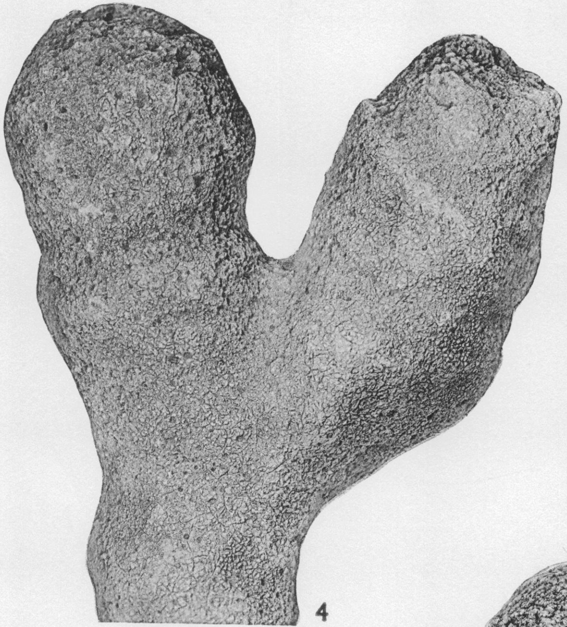
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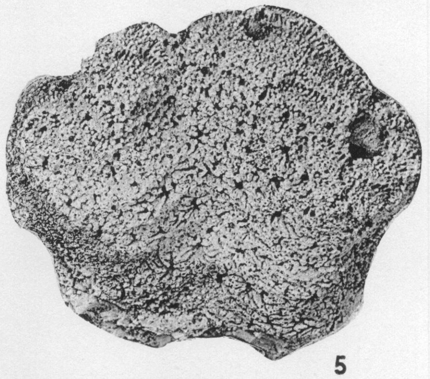
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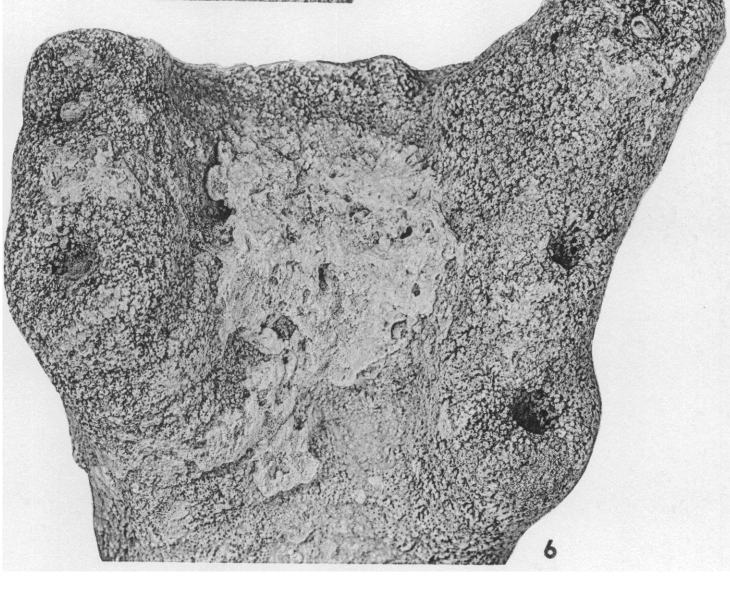
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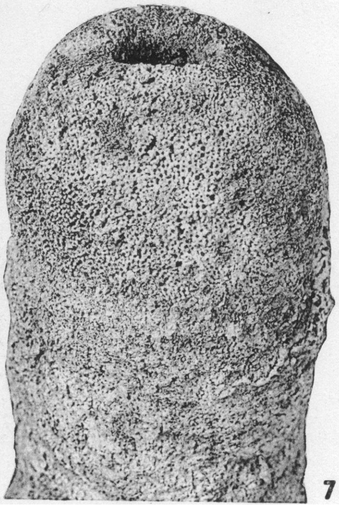
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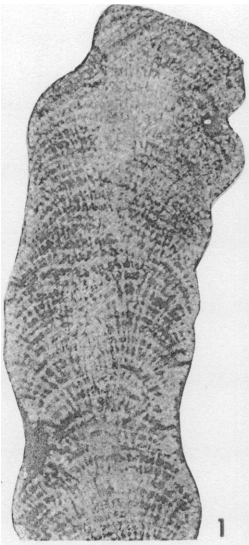
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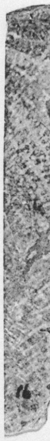
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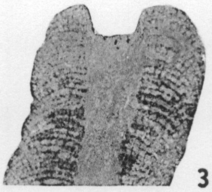
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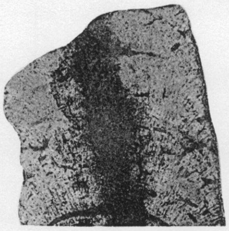
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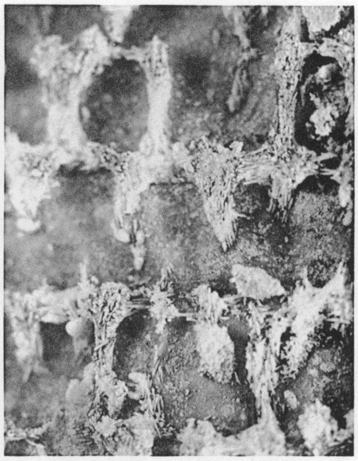
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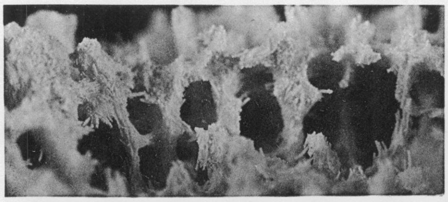
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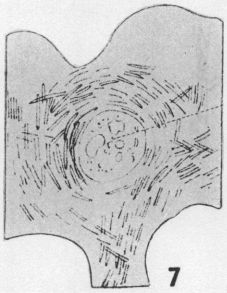
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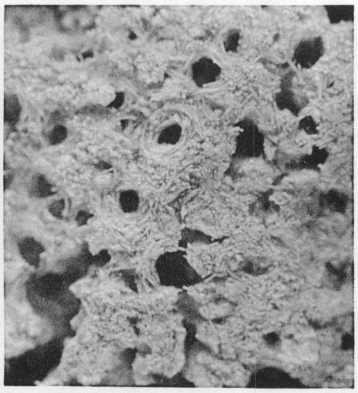
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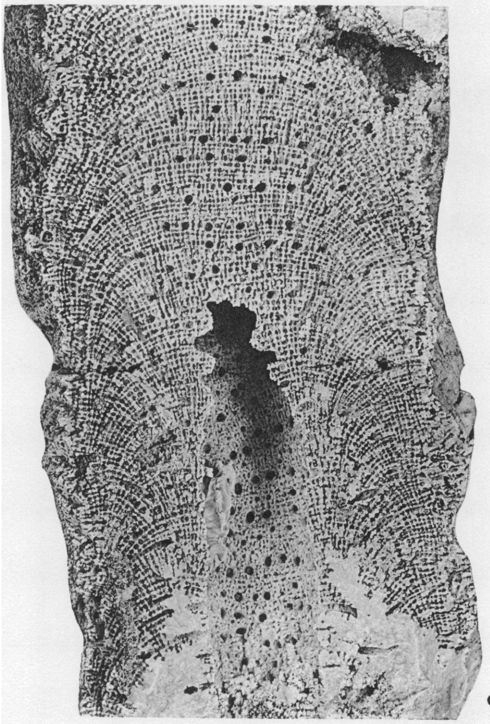
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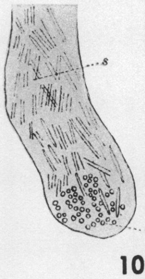

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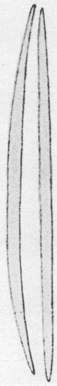
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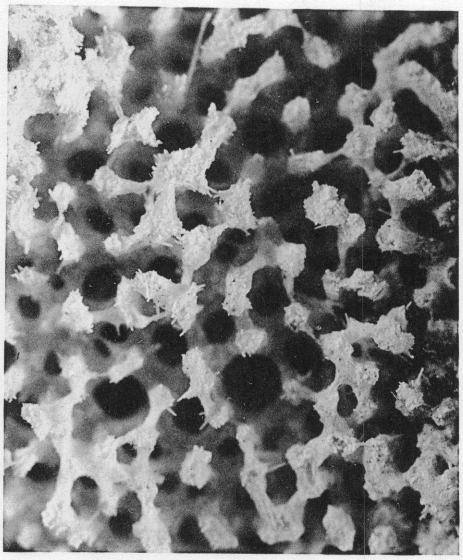
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PLATE 2

1, 2. *Heliospongia excavata* King. 1. Median longitudinal section, topotype, U.S.N.M. No. 127582f, from U.S.N.M. 518f, Graford formation. 2. Longitudinal section showing cloacal pit at upper right and tapering end of similar pit in center, topotype, U.S.N.M. No. 127582g, from same locality.

3. *Heliospongia ramosa* Girty. Median longitudinal section, U.S.N.M. No. 127583, from U.S.N.M. 518o, shale below Stanton (?) limestone.

4. *Heliospongia* sp. cf. *H. vokesi* King. Median longitudinal section, U.S.N.M. No. 127585, from U.S.N.M. 707o, Wolfcamp shale.

5, 6, 8, 12. *Heliospongia excavata* King. 5. Longitudinal section of trabecular net magnified to show individual spicules, U.S.N.M. No. 127579a, from U.S.N.M. 510c, Palo Pinto limestone. 6. Similar view of U.S.N.M. 127580b, from U.S.N.M. 518g, Rock Hill limestone. 8. Outer (incurrent) surface of same specimen magnified to show special dermal layer of spicules surrounding skeletal pores. 12. Cross section of same specimen magnified to show ends of vertical trabeculae and connecting horizontal trabeculae.

7, 10, 11. *Pharetrospongia strahani* Sollas, from "Coprolite bed," Cambridge Greensand, Cretaceous, Cambridgeshire, England. From Sollas (1877, pl. 11). 7. Part of mesh on excurrent surface magnified to show spicules surrounding a skeletal pore (Sollas, 1877, pl. 11, fig. 7). Compare with 8 of this plate. 10. Magnified view of longitudinal section of spicule bundle joining a transversely sectioned bundle at lower end (Sollas, 1877, pl. 11, fig. 6). 11. Isolated oxeas much enlarged (Sollas, 1877, pl. 11, fig. 9).

9. *Heliospongia vokesi* King. Longitudinal section cutting cloaca obliquely and showing apochetes following the horizontal trabeculae and prosochetes following the vertical trabeculae, U.S.N.M. No. 127588d, from U.S.N.M. 702d, Leonard formation.

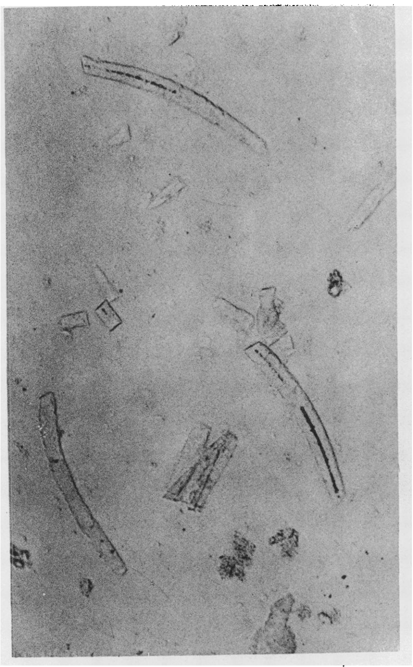
1–5 and 9 are natural size; 5, 6, 8, and 12 are 10 times natural size; 7 and 10 are 30 times natural size; and 11 is 218 times natural size.

PLATE 3

1. *Heliospongia excavata* King. Isolated, incomplete spicules, mounted in balsam and viewed by transmitted light, showing axial canals filled with secondary mineral matter, from specimen illustrated on plate 1, figure 3, U.S.N.M. No. 127581, from U.S.N.M. 518g, Rock Hill limestone.

2–4. *Heliospongia ramosa* Girty. All are from U.S.G.S. 2520 green, Plattsburg ("Allen") limestone. 2. Thin section in horizontal plane, trabeculae appearing light, interspaces dark, showing bundles of monaxons viewed longitudinally in the horizontal trabeculae (center) and in cross section (as circles) where vertical trabeculae are intersected, paratype, U.S.N.M. No. 53472b. 3. Thin section of same specimen in vertical plane, paratype, U.S.N.M. No. 53472a. 4. Another part of section shown in 2, showing a trabecula extending into the cloaca without calcite cement between spicules.

1 is 90 times natural size, and 2–4 are 50 times natural size.



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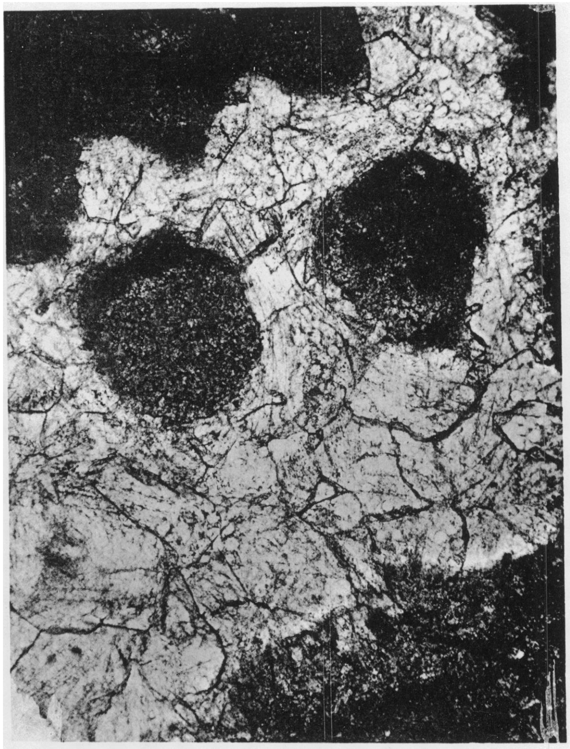

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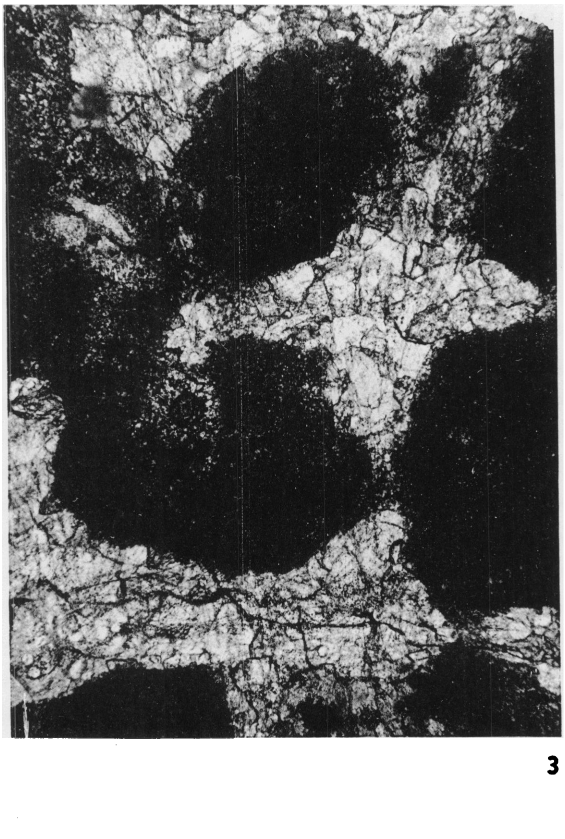

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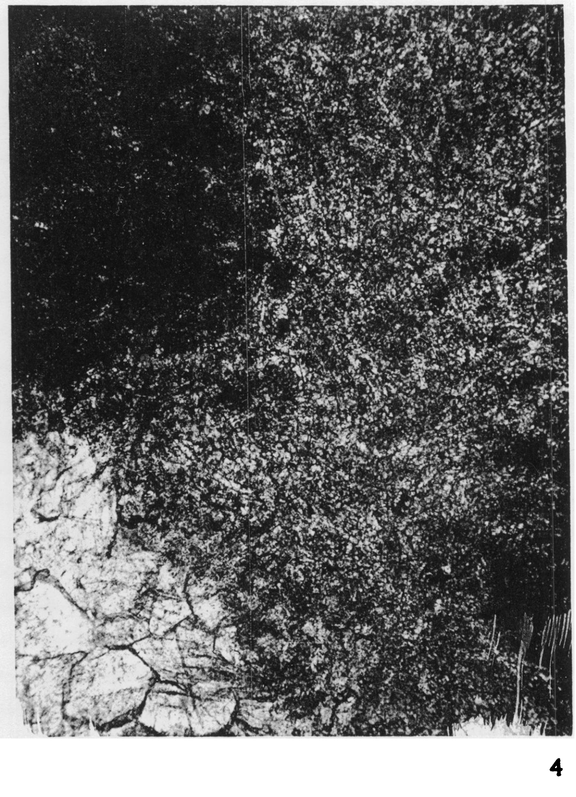

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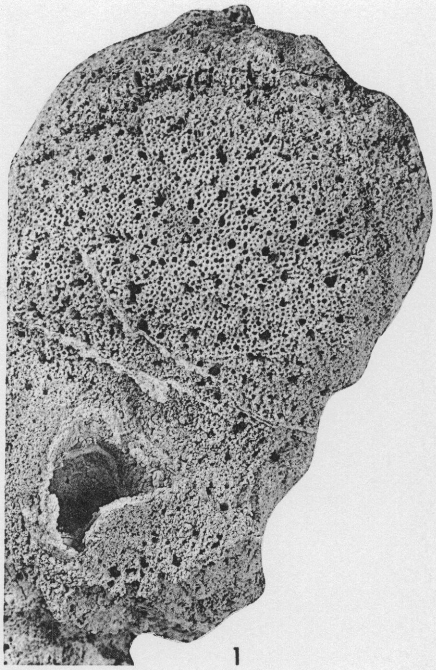
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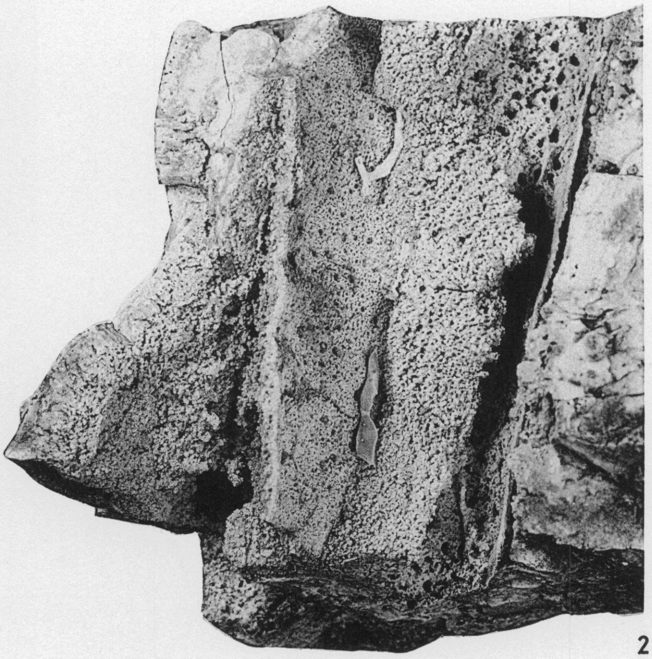
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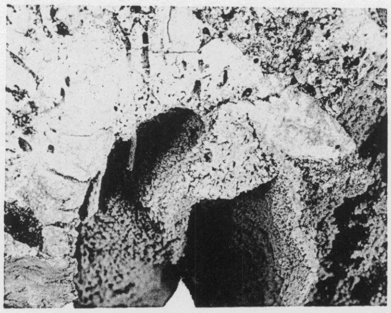
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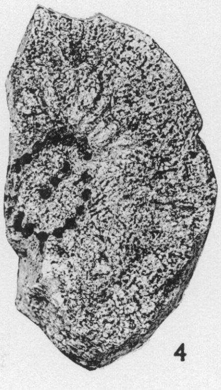
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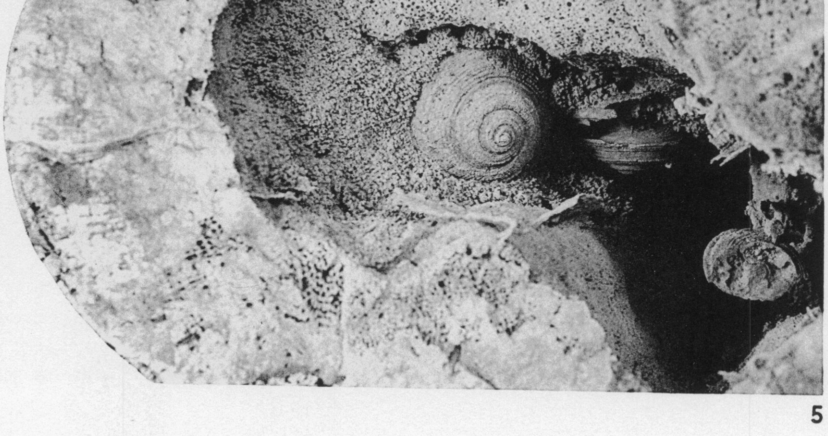
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PLATE 4

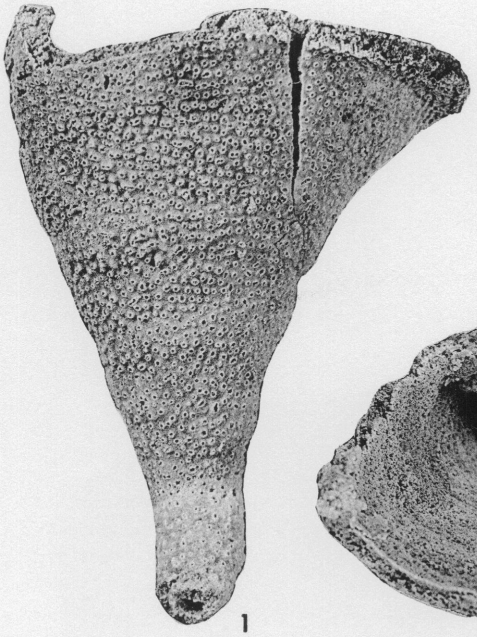
Heliospongia vokesi King. 1. Side of branch showing incurrent pores as well as an epoecious richthofenid brachiopod overgrown by the sponge, topotype, U.S.N.M. No. 127587a, from U.S.N.M. 705a, Leonard formation. 2. Longitudinal section showing wall of cloaca with projecting ridge of adventitious tissue extending downward from large pores at upper right, U.S.N.M. No. 127588a, from U.S.N.M. 702d, Leonard formation. 3. Top view of same specimen showing ridge in cross section. 4. Cross section of sponge in which cloaca is completely obliterated by adventitious tissue. The former limit of the cloaca is shown by the ring of apochetes, U.S.N.M. No. 127588c, from U.S.N.M. 702d, Leonard formation. 5. View down into cloaca, showing adventitious tissue filling lower part and enclosing three shells of a probably symbiotic pleurotomariid gastropod, A.M.N.H. No. 28088, from U.S.N.M. 702d, Leonard formation.

All are natural size.

PLATE 5

Coclocladia spinosa Girty. All are from U.S.N.M. 518g, Rock Hill limestome. 1. Funnel-shaped specimen showing strongly lipped prosopores and spiral twisting of funnel, U.S.N.M. No. 127591a. 2. Top of same specimen showing interior of cloaca, with juvenile individual of *Heliospongia excavata* King adherent to cloacal surface and to rim of funnel in upper part of photograph. 3. Other side of same specimen showing much lower rim of funnel on side facing observer. The edge at right is broken, but that at left and center is entire. The *Heliospongia* covers part of the rim and exterior just to the right of the dark spot. 4. Side of a small and nearly complete specimen, strongly asymmetrical and somewhat spirally twisted; the rim in front is entire; U.S.N.M. No. 127592. 5. Top of same specimen showing excurrent surface. 6. Tubular branch, or individual, growing from outer (incurrent) surface of flat frond, U.S.N.M. No. 127591e. 7. Other side of same specimen showing excurrent surface of frond; there is no opening from this surface to the cloaca of the branch. 8. Outer surface of part of large frond, U.S.N.M. No. 127591d. The whole upper edge shown here is unbroken, as is the straight portion of the opposite edge at the very bottom; the sponge grew from left to right, the irregularity in the upper edge being caused by an interruption in growth; at upper right is a tubular branch or adherent individual showing a narrow cloaca where broken across (compare two preceding figures).

All are natural size.



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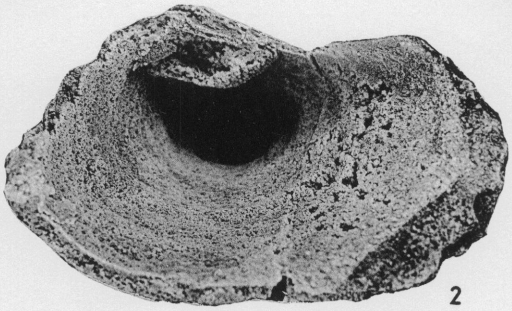

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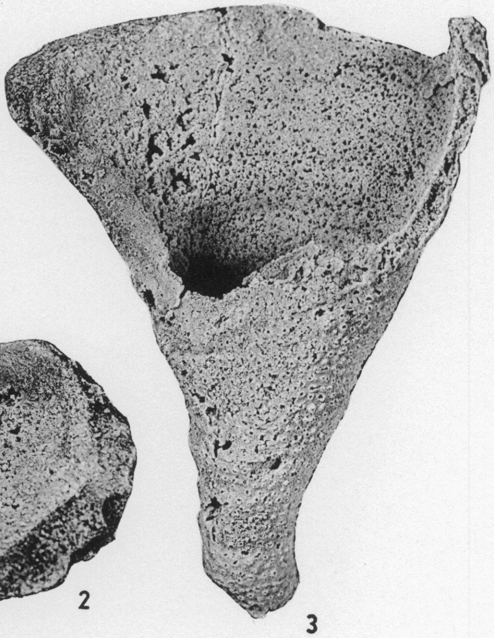

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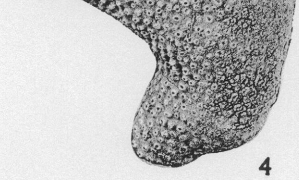

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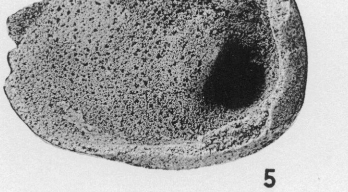

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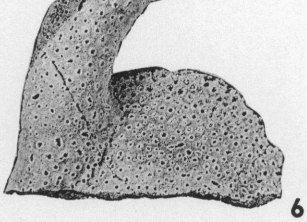

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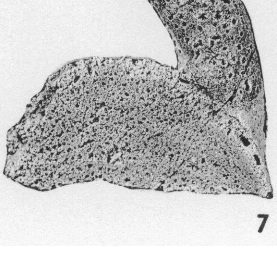

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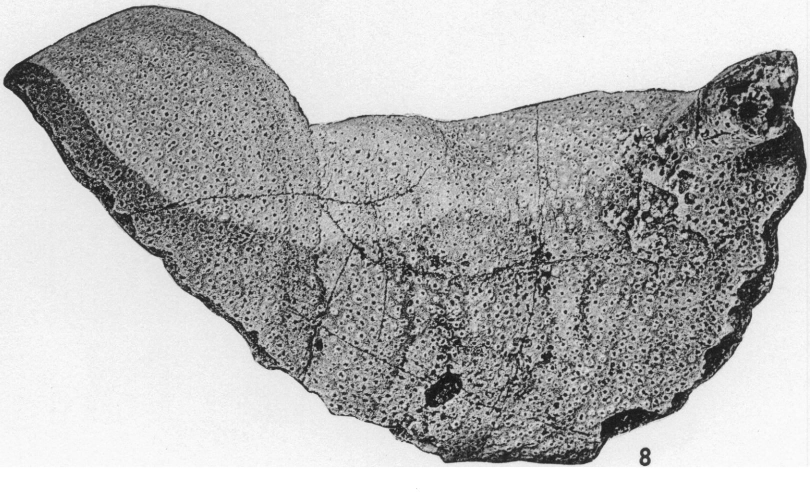

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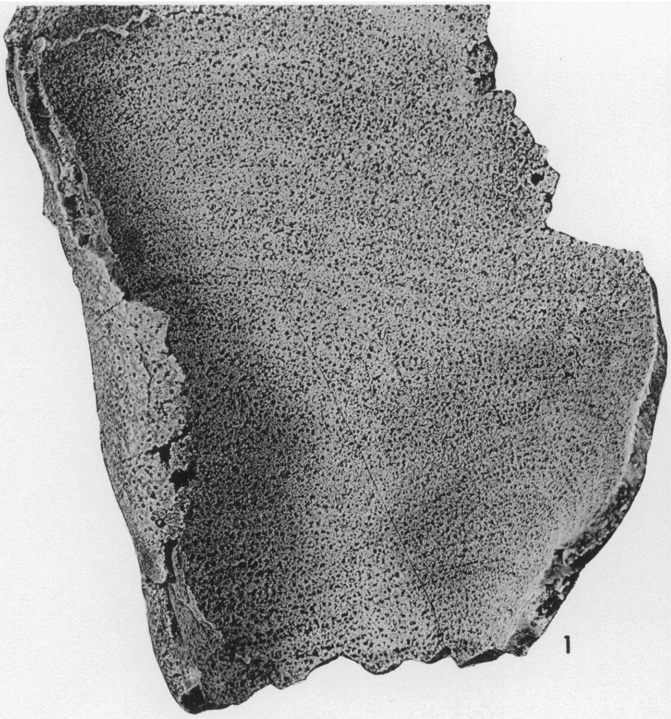

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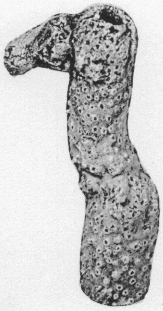

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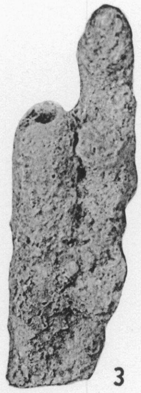

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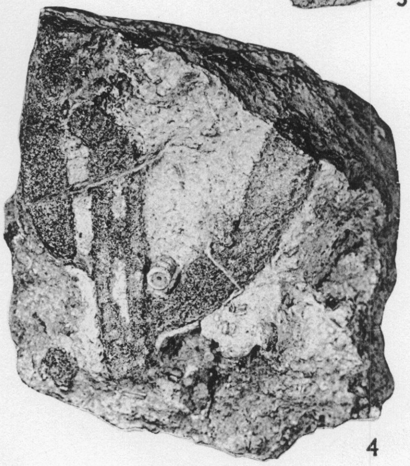

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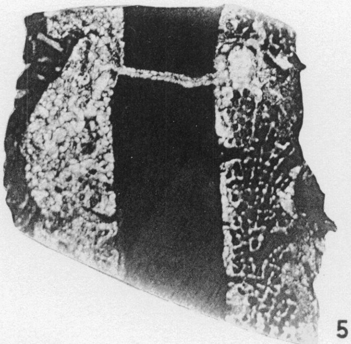

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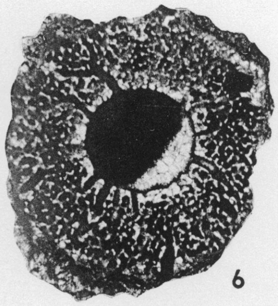

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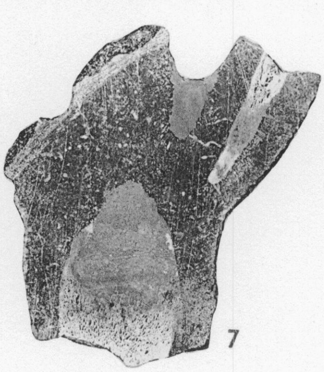

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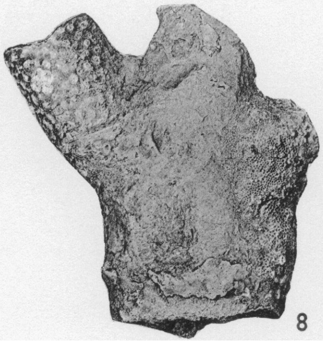

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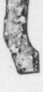

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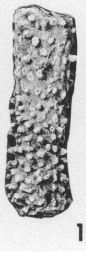

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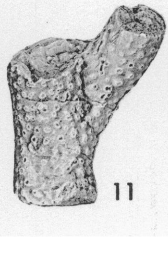

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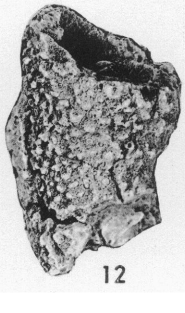

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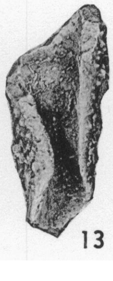

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PLATE 6

Coelocladia spinosa Girty. 1. Inner (excurrent or cloacal) surface of part of large asymmetrical funnel, showing arrangement of apopores in rows parallel to the upper growing edge of the sponge; the edge shown at left, curving towards the observer to reveal the outer surface, is part of the original rim of the funnel, the remaining edges being broken, U.S.N.M. No. 127591c, from U.S.N.M. 518g, Rock Hill limestone. 2. Cylindrical specimen showing oscular end; another individual is adherent at upper left; U.S.N.M. No. 127591f, from U.S.N.M. 518g, Rock Hill limestone. 3. Paratype, showing oscular ends of two cylindrical branches; a broken stub of a third branch is present on the right-hand branch just below the level of the osculum of the left-hand one, U.S.N.M. No. 53469p, from U.S.G.S. 2520 green, Plattsburg ("Allen") limestone. 4. Branching specimen in matrix showing growth form; the cloaca of the main stock is visible in partial longitudinal section, the branch to the right bears an incipient branch on its left side about halfway up from its origin, and a third branch from the main stock is visible in cross section at the center of the top of the block, paratype, U.S.N.M. No. 53469n, from U.S.G.S. 2520 green, Plattsburg ("Allen") limestone. 5. Longitudinal thin section showing trabecular net, same specimen illustrated by Girty (1908, pl. 16, fig. 3), paratype, U.S.N.M. No. 53469c, from U.S.G.S. 2520 green, Plattsburg ("Allen") limestone. 6. Transverse thin section of same specimen, showing trabecular net and apochetes entering cloaca. 7. Longitudinal polished section showing lack of connection between cloaca of branch and that of main stock; the section is median with respect to the branch, but somewhat oblique with respect to the main stock, so that the cloaca of the latter is not present above, U.S.N.M. No. 127590, from U.S.N.M. 518k, Wann shale. 8. Outside of same specimen. 9–13. A series of specimens from U.S.N.M. 518f, Brownwood shale, showing variability in size and shape. 9. U.S.N.M. No. 127593b. 10. U.S.N.M. No. 127593c. 11. U.S.N.M. No. 127593f. 12. U.S.N.M. No. 127593e. 13. A small frondose specimen, showing opposite rims almost meeting in front, U.S.N.M. No. 127593h.

All are natural size, except 5 and 6, which are five times natural size.

PLATE 7

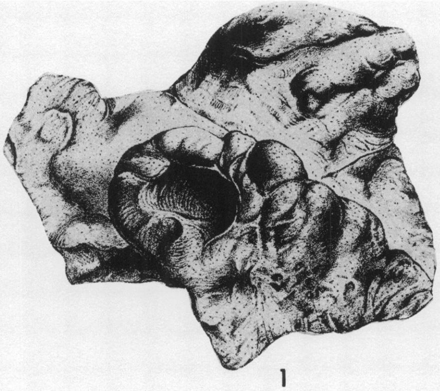
1–3. *Pharetrospongia strahani* Sollas, from "Coprolite bed," Cambridge Greensand, Cretaceous, Cambridge, England. From Sollas (1877, pl. 11). 1. View of plate-like specimen with a tubular projection; the incurrent surface faces the observer except for the lining of the tubular part, which is continuous with the surface of the plate facing away from the observer, and is an excurrent surface (Sollas, 1877, pl. 11, fig. 1). 2. A portion of the excurrent surface (Sollas, 1877, pl. 11, fig. 2). 3. A portion of the incurrent surface (Sollas, 1877, pl. 11, fig. 3).

4–6. *Coelocladia spinosa* Girty. 4. Part of the excurrent surface enlarged to show two sizes of apopores as well as the arrangement of the larger apopores in rows, vertical in this photograph, parallel to the growing edge (compare pl. 6, fig. 1), U.S.N.M. No. 127593L, from U.S.N.M. 518f, Brownwood shale. 5. Part of the incurrent surface of same specimen enlarged to show arrangement of prosopores. 6. Part of incurrent surface of another specimen enlarged to show coalescence of the lips of adjacent prosopores, U.S.N.M. No. 127593k, from U.S.N.M. 518f, Brownwood shale.

7–9. *Coelocladiella lissa* Finks, new species. 9. Exterior of holotype with cross section exposed above (cloaca filled with matrix), U.S.N.M. No. 127595, from U.S.N.M. 700, Gaptank formation. 10. Transverse polished section of same specimen enlarged to show trabecular net of part of body wall, the cloaca at the left. 11. Longitudinal polished section of same specimen enlarged to show trabecular net of part of body wall, the cloaca at the left; the upward and outward divergence of some of the trabeculae can be seen.

10. *Coelocladia spinosa* Girty. Transverse thin section showing oxeas. A complete oxea, slightly concave to the left and oriented vertically, is visible 25 mm. from the left edge of the photograph, extending from 30 mm. to 45 mm. below the upper edge; a similar oxea, slightly inclined towards the upper right, is centered about 28 mm. from the right edge and 29 mm. from the lower edge; a bundle of juxtaposed parallel oxeas is faintly visible in the lower right corner. U.S.N.M. No. 127589, from U.S.N.M. 518i, shale above Torpedo sandstone.

7 is natural size; 4–6, 8, and 9 are five times natural size; 10 is 50 times natural size; 1 is one-half natural size; and 2 and 3 are eight-tenths natural size.



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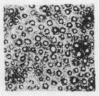

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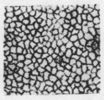

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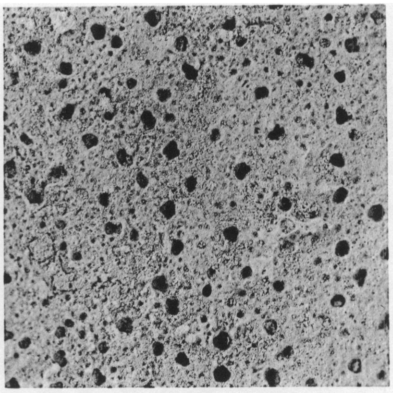

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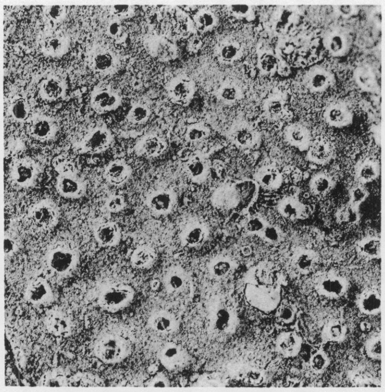

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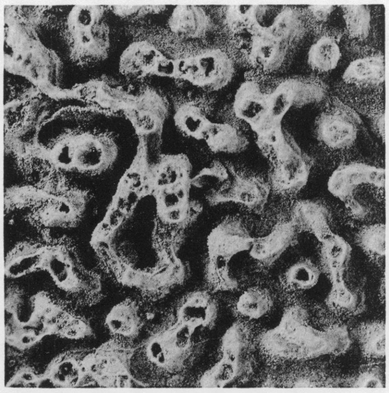

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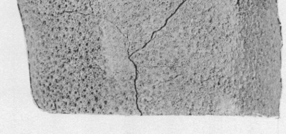

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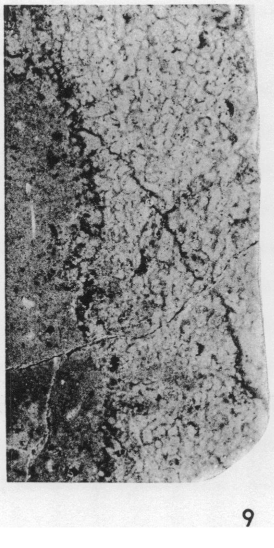

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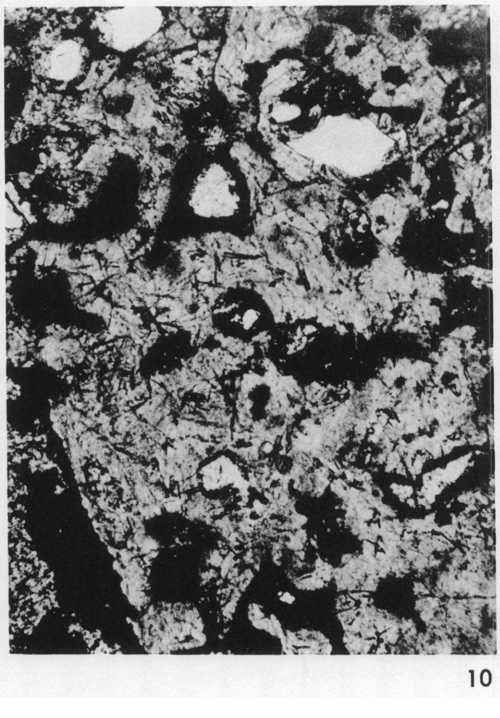

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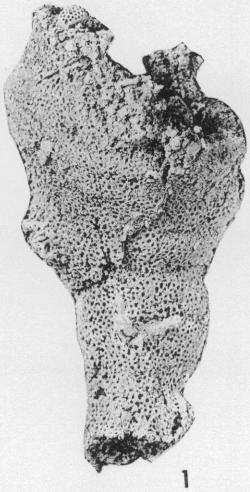

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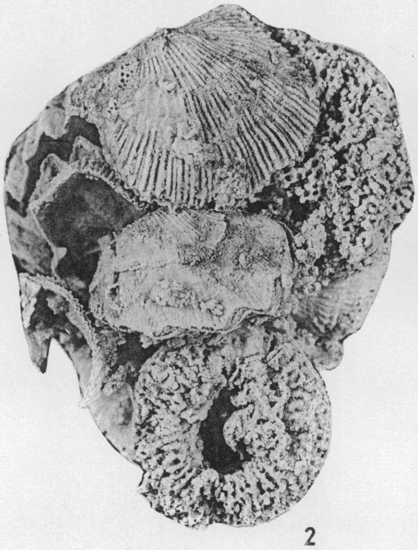

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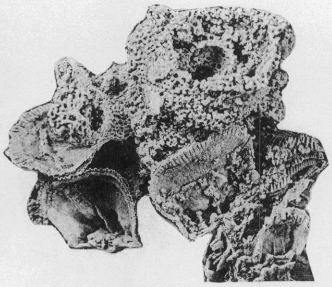

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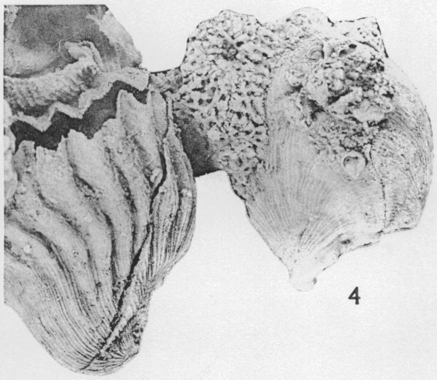

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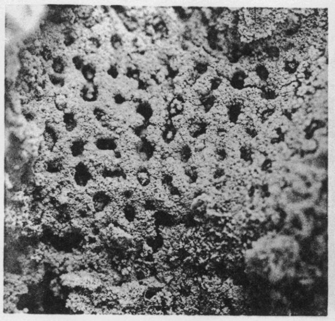

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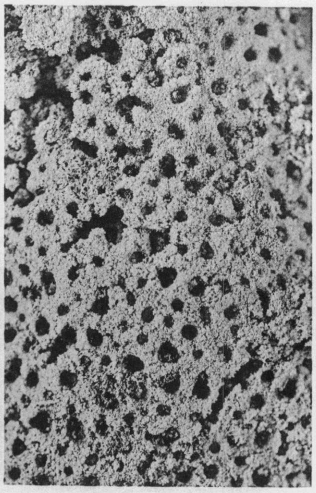

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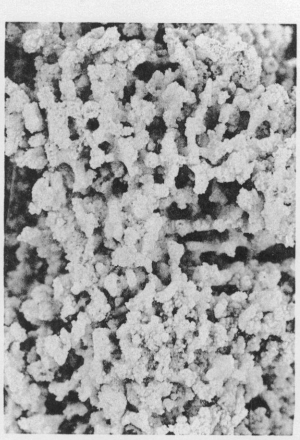

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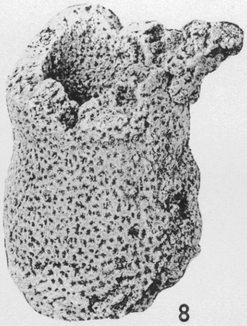

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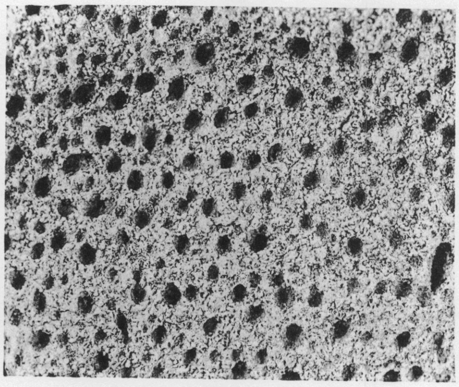

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PLATE 8

1–7. *Coelocladiella philoconcha* Finks, new species. 1. Side of holotype showing prosopores, U.S.N.M. No. 127598, from U.S.N.M. 701L, Wolfcamp formation. 2. Top of paratype attached to brachiopod shells, showing radial structure of trabeculae in individual at bottom, U.S.N.M. No. 127597a, from U.S.N.M. 701L, Wolfcamp formation. 3. Paratype, showing cloacal pores and brachiopod shells molded around it, U.S.N.M. No. 127597c, from U.S.N.M. 701L, Wolfcamp formation. 4. Complete juvenile individual growing between brachiopods and molded to both, paratype, U.S.N.M. No. 127597a, from U.S.N.M. 701L, Wolfcamp formation. 5. Magnified view of cloacal wall of holotype showing apopores, U.S.N.M. No. 127598, from U.S.N.M. 701L, Wolfcamp formation. 6. Magnified view of outer surface of same specimen, showing prosopores. 7. Magnified view of vertical section of body wall, showing arrangement of trabeculae, paratype, U.S.N.M. No. 127598b, from U.S.N.M. 701L, Wolfcamp formation.

8. *Coelocladiella lissa* Finks, new species. Side of fragmentary specimen, with cloaca exposed above, showing prosopores on exterior and apopores lining cloaca, U.S.N.M. No. 127594, from U.S.N.M. 715d, Wolfcamp formation.

9. *Coelocladia spinosa* Girty. Magnified view of what is probably the excurrent surface of a frond of this species, U.S.N.M. No. 127631, from U.S.N.M. 700, Gaptank formation. Compare with plate 7, figure 4, same magnification, where the apopores are more widely spaced.

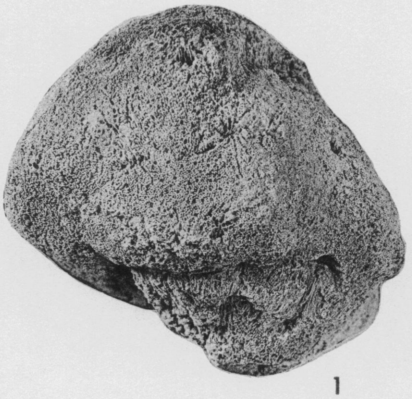
1, 3, and 8 are natural size; 2 and 4 are twice natural size; and 5, 6, 7, and 9 are five times natural size.

PLATE 9

1–3. *Multistella porosa* Finks, new species. 1. Side view of holotype showing characteristic overhang of upper part of sponge, U.S.N.M. No. 127600, from A.M.N.H. 512, Cherry Canyon formation. 2. Basal view of same specimen showing radial structure of skeleton, clearest at lower left; the concentrically wrinkled, imperforate, basal layer is poorly developed on this specimen but may be discerned above the center of the photograph. 3. Top view of same specimen showing stellate clusters of apopores.

4–6. *Phacellopegma schizoderma* Finks, new species. 4. Side view of holotype, showing pattern of clefts and pores, U.S.N.M. No. 127599, from Marble Falls limestone, Marble Falls, Texas. 5. Top of same specimen; the large open space, lower right, was probably not a cloaca. 6. Base of same specimen, showing radial structure of skeleton and, in center, the other end of large hole shown in preceding figure.

All are natural size.



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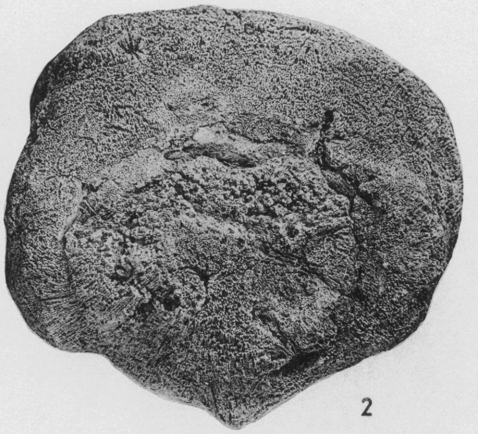

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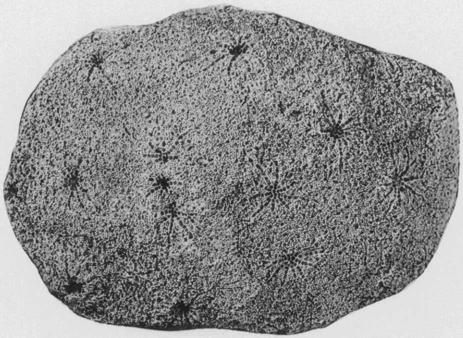

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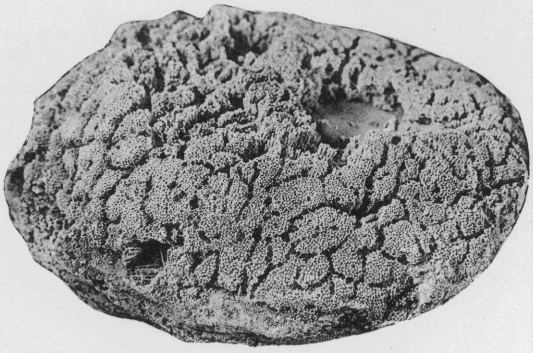

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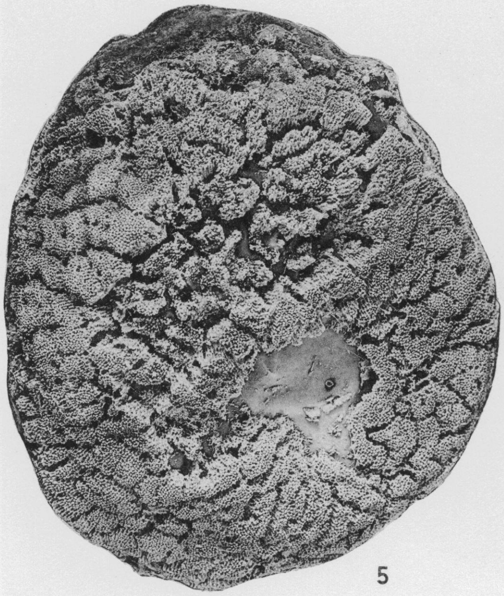

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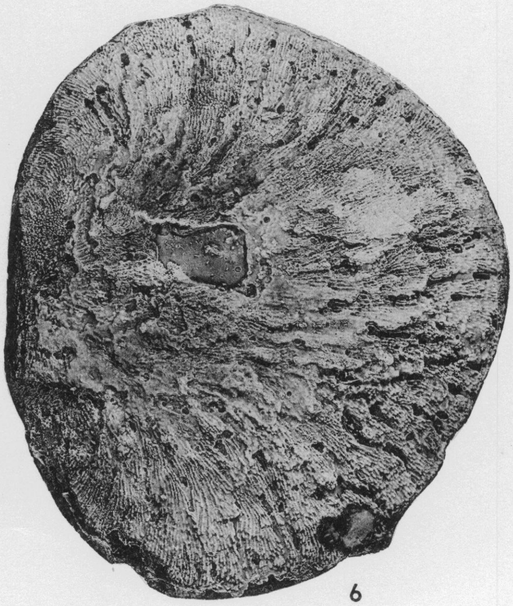

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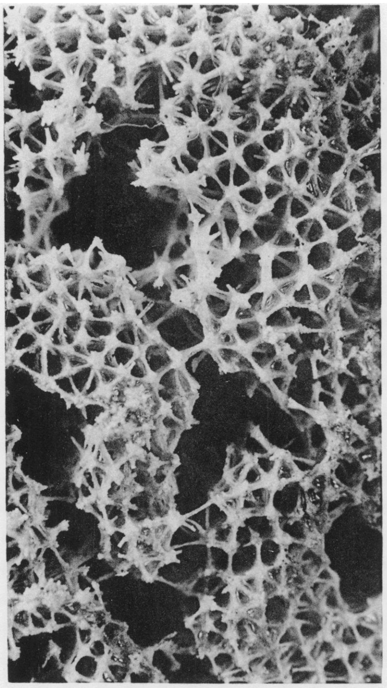
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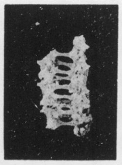
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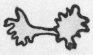
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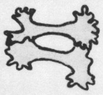
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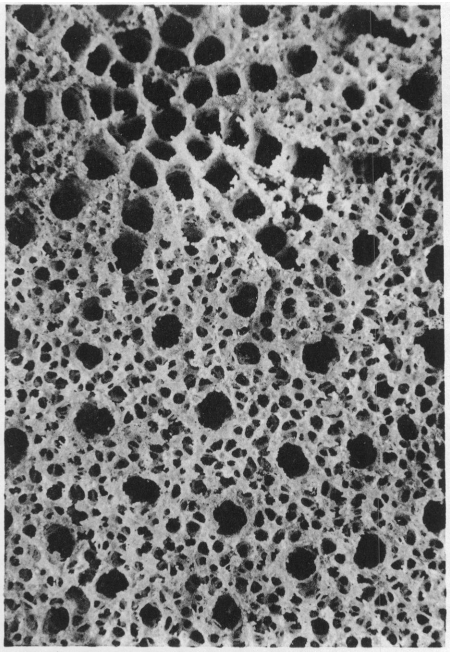
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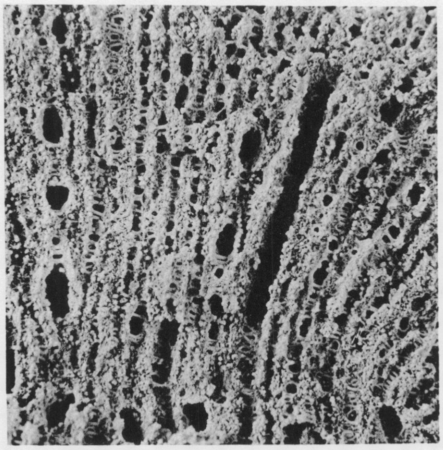
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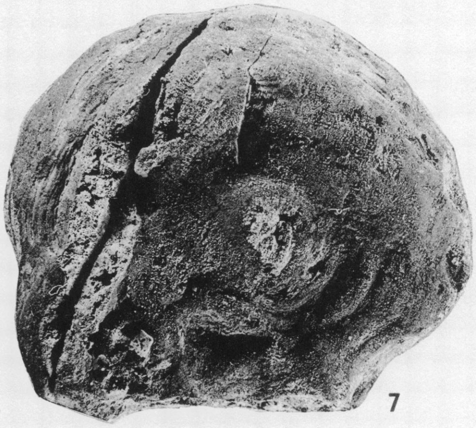
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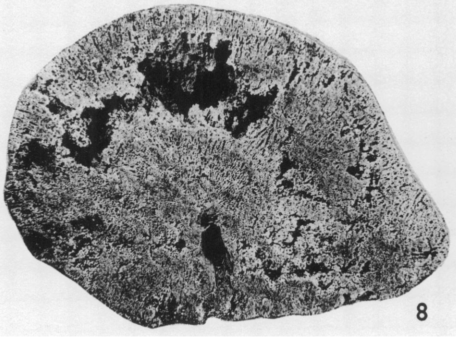
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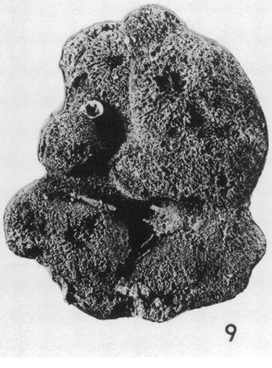
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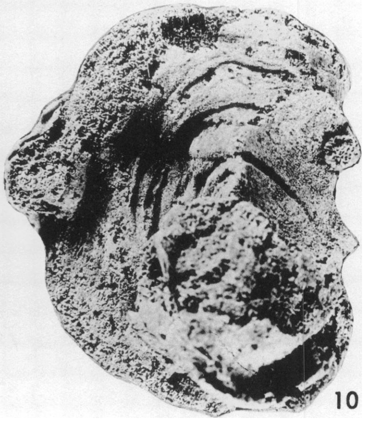
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PLATE 10

1, 2. *Phacellopegma schizoderma* Finks, new species. 1. Magnified view of top surface showing pores and spoke-like arrangement of spicules, holotype, U.S.N.M. No. 127599, from Marble Falls limestone, Marble Falls, Texas. 2. Isolated portion of radial, ladder-like series of dendroclones from same specimen.

3–8. *Multistella porosa* Finks, new species. 3. Outline sketch of isolated dendroclone from paratype, A.M.N.H. No. 28089, from A.M.N.H. 21SW, Cherry Canyon formation. 4. Two dendroclones from same specimen, united as they are in the radial series. 5. Magnified view of top surface of holotype, showing stellate cluster of apopores at upper left and spoke-like arrangement of spicules, U.S.N.M. No. 127600, from A.M.N.H. 512, Cherry Canyon formation. 6. Magnified view of side surface of same specimen, showing natural section parallel to radial spicule series and cross sections of canals normal to the spicule series. 7. Imperforate, concentrically wrinkled, basal surface of paratype, A.M.N.H. No. 28089, from A.M.N.H. 21SW, Cherry Canyon formation. 8. Vertical section of same specimen showing spicule series radiating from the mold of a brachiopod shell, which appears as a dark area just above base; this was the original attachment of the sponge, but it subsequently overgrew it completely.

9, 10. Chiastoclonellid, genus and species undetermined. Both from A.M.N.H. 512, Cherry Canyon formation. 9. Top surface showing somewhat stellate pore clusters, A.M.N.H. No. 28092. 10. Imperforate concentrically wrinkled, basal surface, A.M.N.H. No. 28092:1.

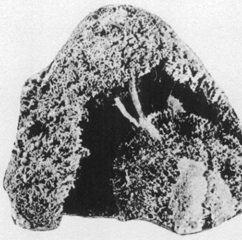
7–9 are natural size; 10 is twice natural size; 1, 2, 5, and 6 are 10 times natural size; and 3 and 4 are approximately 50 times natural size.

PLATE 11

1. Chiastoclonellid, genus and species undetermined. Side view of natural section showing radial structure of skeleton and silica steinkerns of two canals, probably apochetes, A.M.N.H. No. 28092:2, from A.M.N.H. 512, Cherry Canyon formation.

2–10. *Insulipora elegans* Finks, new species. 2. Juvenile individual which apparently grew around a slender rod-like object, such as a brachiopod spine, that passed through the long axis of the sponge and is now preserved as a mold (not visible); the depression at left is an artifact, U.S.N.M. No. 127603a, from U.S.N.M. 705a, Leonard formation. 3. Top surface of holotype showing distribution of oscules, pores, and surface grooves, U.S.N.M. No. 127601, from U.S.N.M. 707q, Leonard formation. 4. Base of same specimen showing concentrically wrinkled surface. 5–8. Outline drawings of isolated spicules from same specimen. 9. Polished section of paratype parallel to base, showing dense texture of skeletal net and distribution of apochetes, U.S.N.M. No. 127602, from U.S.N.M. 707q, Leonard formation. 10. Magnified view of top surface of holotype, showing spicules, skeletal pores, and larger pores, U.S.N.M. No. 127601, from U.S.N.M. 707q, Leonard formation.

1 is natural size; 2–4 and 9 are twice natural size; 10 is five times natural size; and 5–8 are about 40 times natural size.



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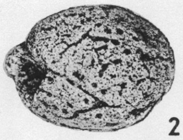

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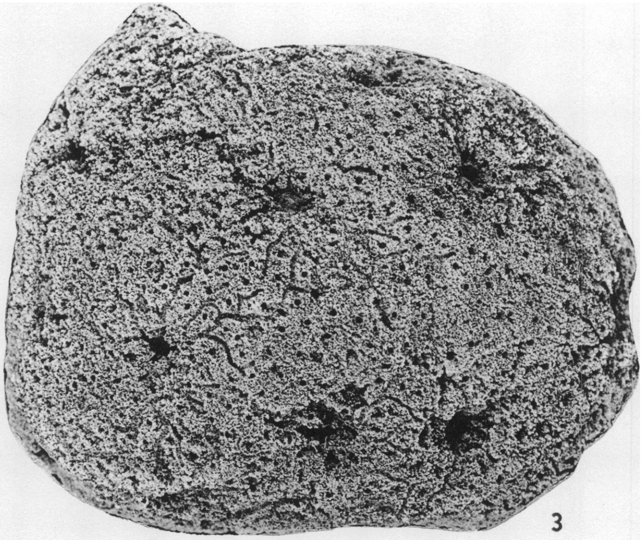

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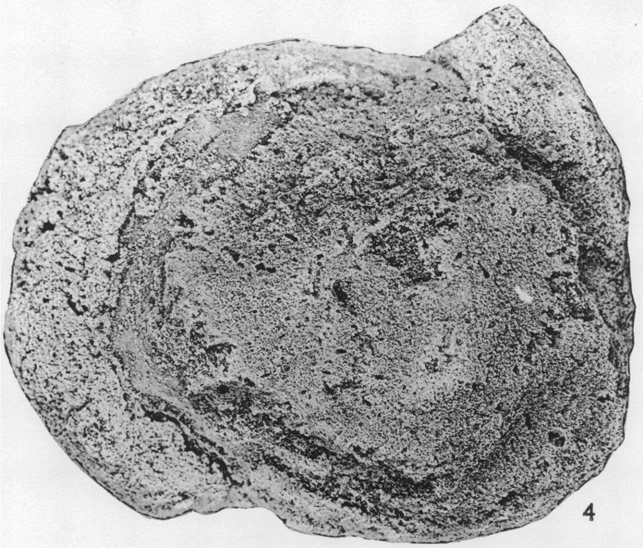

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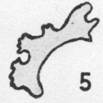

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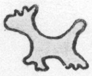

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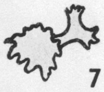

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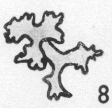

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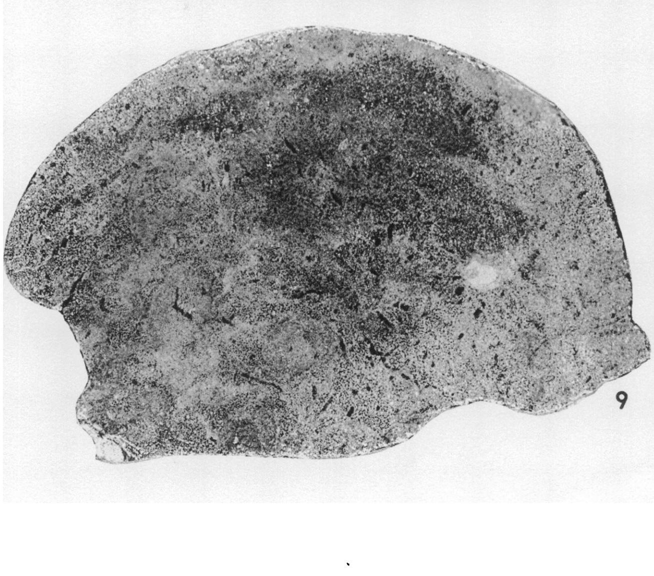

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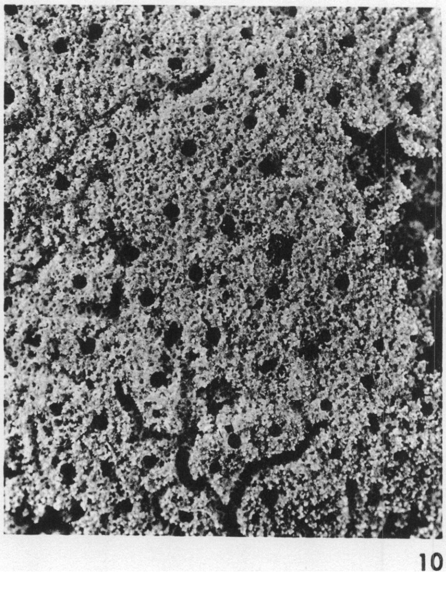

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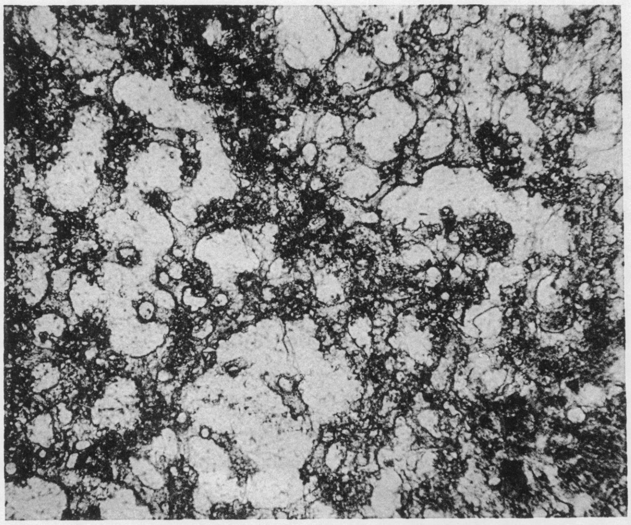

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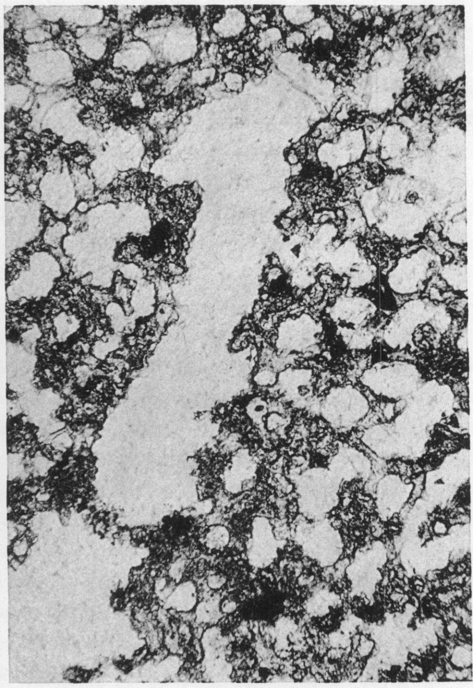

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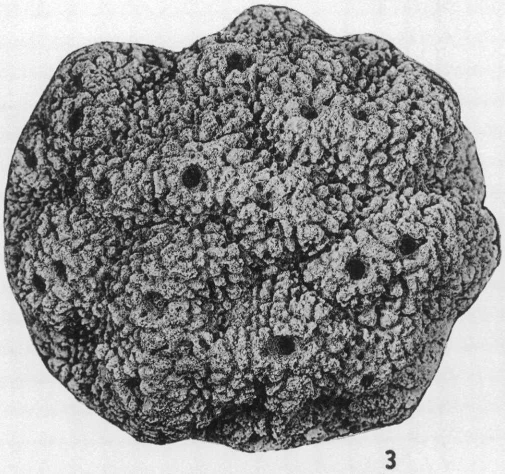

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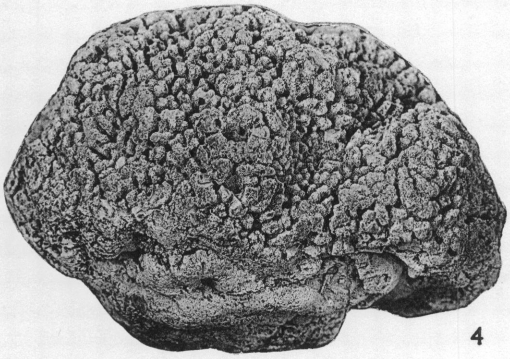

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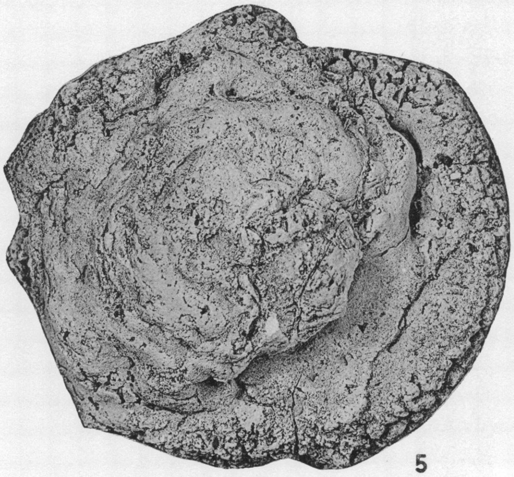

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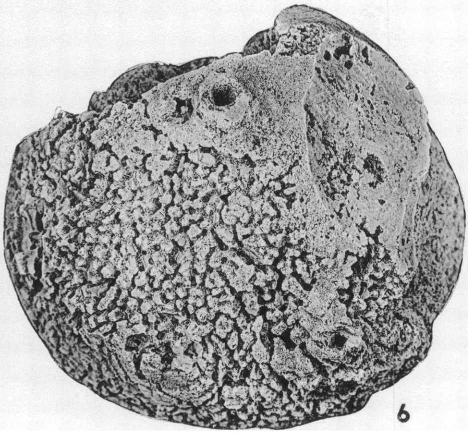

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PLATE 12

1, 2. *Insulipora elegans* Finks, new species. 1. Thin section of paratype showing spicular net consisting largely of chiastoclones, U.S.N.M. No. 127602a, from U.S.N.M. 707q, Leonard formation. 2. Thin section of same specimen showing apochete sectioned longitudinally.

3–6. *Defordia defuncta* King. 3. Top of characteristic individual showing oscules at the summits of mammillose protuberances, as well as smaller pores connected by deep surface grooves, topotype, U.S.N.M. No. 127604h, from U.S.N.M. 705a, Leonard formation. 4. Side of same specimen showing top surface overhanging imperforate basal surface. 5. Base of same specimen showing concentrically wrinkled, imperforate surface. 6. Top of another topotype with smoothly rounded surface and few oscules; the square openings at top center and at lower right are molds of *Conularia* sp. cf. *C. leonardensis* Finks enclosed in the sponge, U.S.N.M. No. 127604i, from U.S.N.M. 705a, Leonard formation.

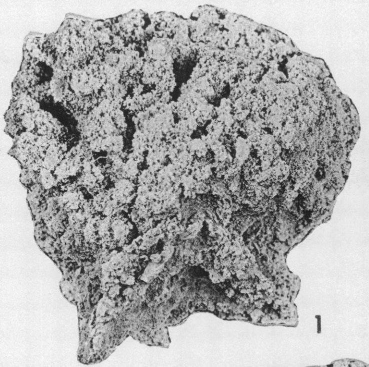
3–6 are natural size, and 1 and 2 are 50 times natural size.

PLATE 13

1–7. *Defordia defuncta* King. All are topotypes from U.S.N.M. 705a, Leonard formation. 1. Enlarged side view of juvenile, U.S.N.M. No. 127604b. 2. Enlarged view of two juveniles growing in opposite directions from a common attachment; overhang of top surface over imperforate basal surface can be seen, U.S.N.M. No. 127604d. 3. Top of small aberrant specimen having smooth surface with well-developed furrows, U.S.N.M. No. 127604a. 4. Base of same specimen showing concentric wrinkles. 5. Enlarged side view of somewhat cylindrical juvenile, showing imperforate basal layer in lower half, U.S.N.M. No. 127604e. 6. Magnified view of top surface showing spicular net, U.S.N.M. No. 127604f. 7. Natural vertical section showing characteristic large anastomosing spaces of interior, U.S.N.M. No. 127604g.

8, 9. Top surface of aberrant individual resembling *Defordia densa* Finks, new species, with relatively closely spaced pores, U.S.N.M. No. 127604j. 9. Magnified view of surface of same specimen; compare with more typical specimen shown in 6.

3, 4, 7, and 8 are natural size; 1, 2, and 5 are twice natural size; and 6 and 9 are five times natural size.



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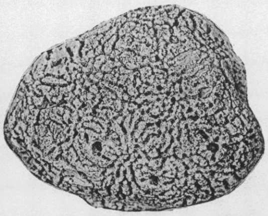

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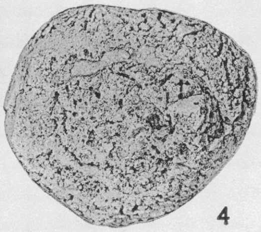

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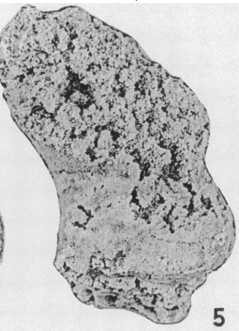

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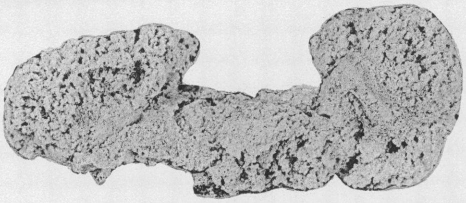

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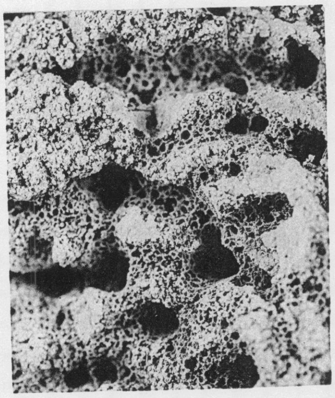

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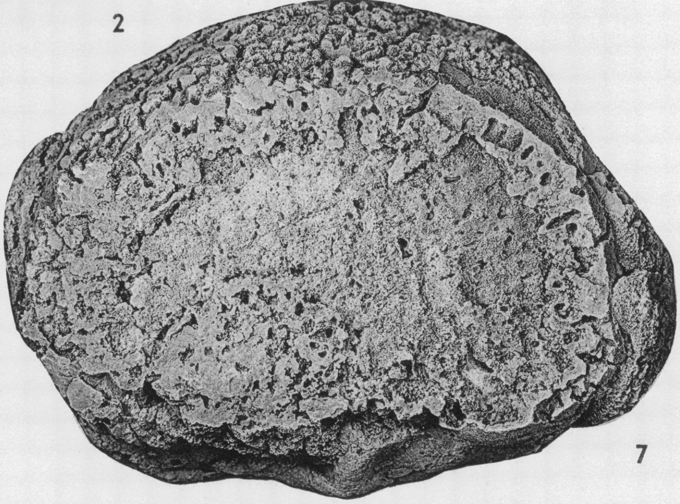

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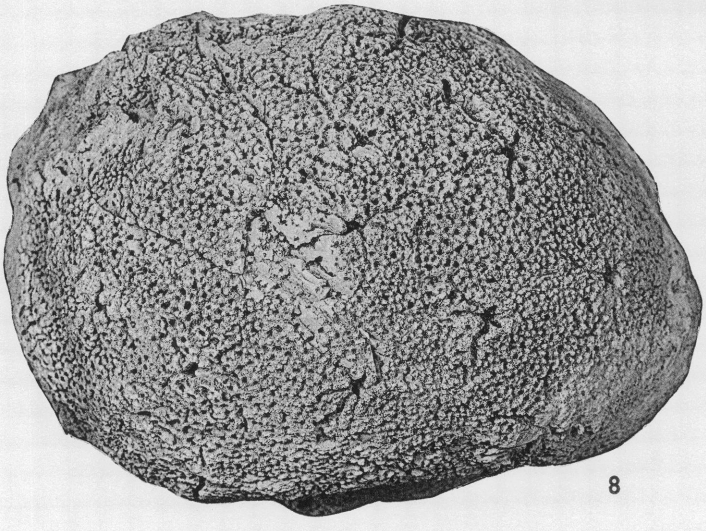

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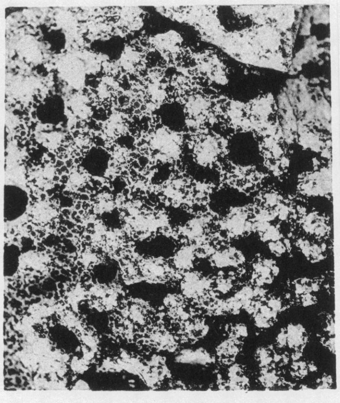

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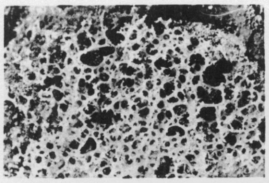

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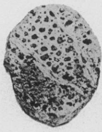

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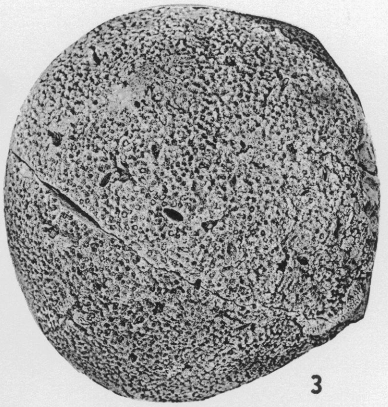

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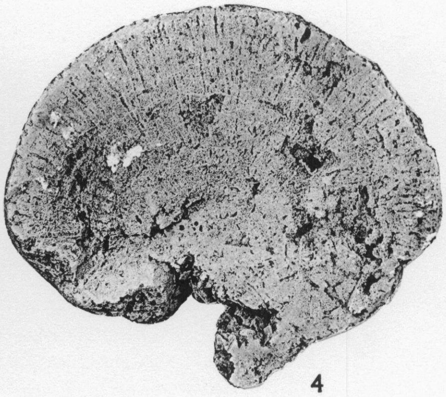

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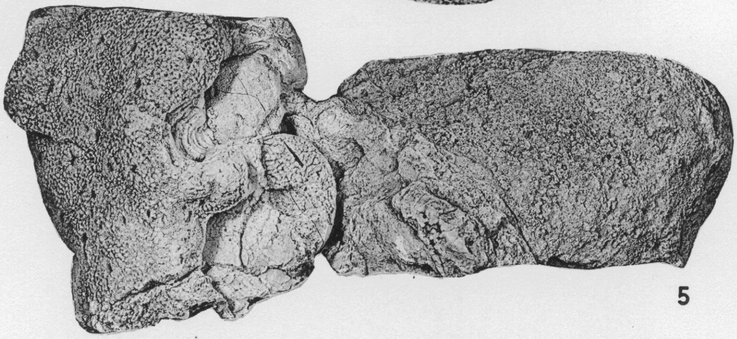

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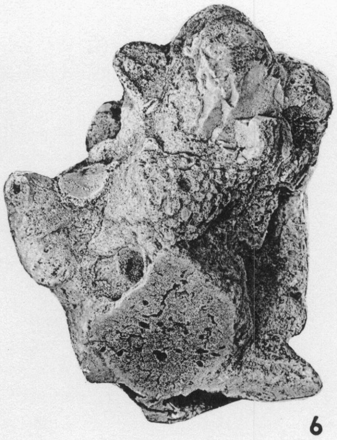

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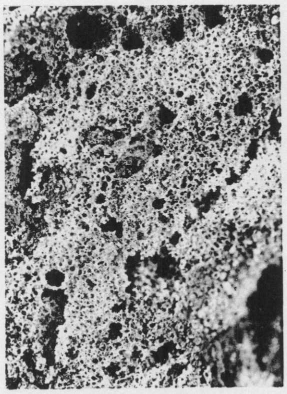

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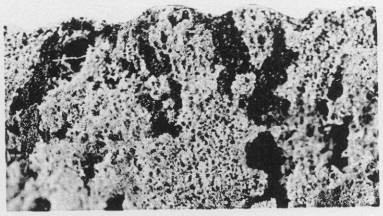

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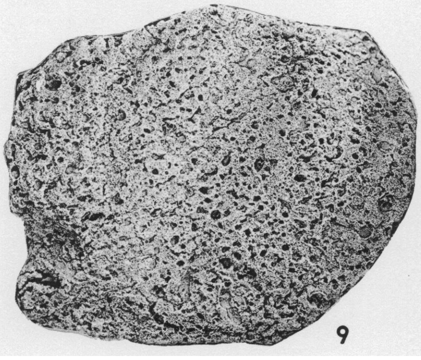

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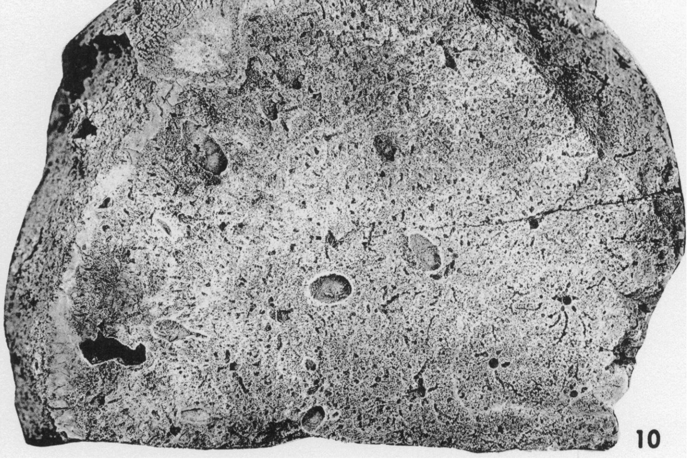

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PLATE 14

1, 2. Tetracladine sponge, genus and species undetermined. 1. Magnified view of spicular net on broken surface normal to sponge surface, A.M.N.H. No. 28091, from A.M.N.H. 547, Cherry Canyon formation. 2. Surface of same specimen.

3–6. *Defordia densa* Finks, new species. 3. Top of spheroidal individual; the elongate holes were formed by an unidentified epoecious organism embedded in the sponge, paratype, P.U. No. 78871, from P.U. 77, Bone Spring limestone. 4. Sagittal section of same specimen showing radial canals. 5. Reduced top view of holotype, a large, flat, somewhat incomplete specimen; oscules are visible at the left; immediately to the right of this area part of the concentrically wrinkled, imperforate basal surface can be seen; to the right of this a spheroidal bryozoan colony is visible, growing on, and partly overgrown by, the sponge, P.U. No. 78867, from P.U. 1rc, Bone Spring limestone. 6. A specimen with digitate processes, each bearing an oscule, paratype, P.U. No. 78889, from P.U. 10, Bone Spring limestone.

7–9. *Defordia* sp. cf. *D. densa* Finks, new species. 7. Magnified view of top surface showing spicular net, U.S.N.M. No. 127607a, from U.S.N.M. 707q, Leonard formation. 8. Magnified view of sagittal section of same specimen, upper surface at top, showing arrangement of spicules in poorly defined vertical series. 9. Top surface of same specimen.

10. *Defordia densa* Finks, new species. Section, somewhat tangential, showing, at lower left, cross sections of apochetes with radially arranged tributary canals; the numerous oval hollows are oblique sections of imperforate conical tubes which probably housed an organism that lived embedded in the sponge; at upper left is a section of a funnel-shaped depression in the sponge surface possibly caused by an epoecious organism, P.U. No. 78868, from P.U. 1rc, Bone Spring limestone.

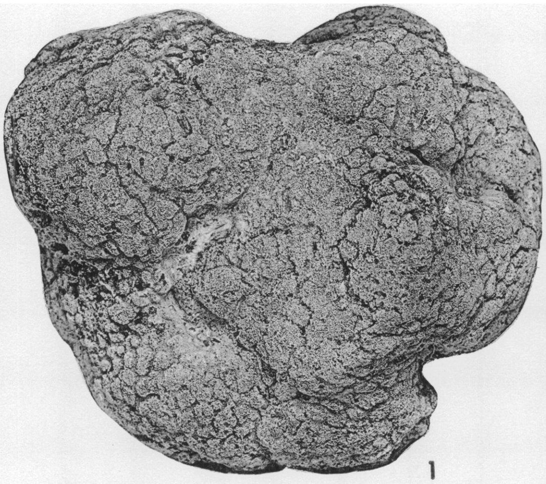
2, 3, 4, 6, 9, and 10 are natural size; 5 is one-half natural size; and 1, 7, and 8 are five times natural size.

PLATE 15

1–4. *Defordia* sp. 1. View of surface which may or may not be the top, U.S.N.M. No. 127610, from U.S.N.M. 707q, Leonard formation. 2. Opposite side of same specimen. 3. Magnified view of surface of same specimen showing spicular net and surface grooves. 4. Side view of same specimen; the surface shown in 1 is at the bottom.

5–12. *Defordia lobata* Finks, new species. All are from U.S.N.M. 707ha, Leonard or Wolfcamp formation. 5. Part of a vertical section of holotype showing dense net and radial canals at left; the looser material at right is adherent shell debris and not part of the sponge, U.S.N.M. No. 127608. 6. Probable basal surface of same specimen; note patches of imperforate surface, the patch at top left shows concentric wrinkles; the monaxial spicule fragments adherent to the surface do not belong to this sponge. 7. Opposite surface of same specimen, showing single oscule at upper right and patches of imperforate surface in sulci. 8, 9. Small, rounded pebbles, possibly abraded fragments of this species, U.S.N.M. No. 127609d. 10. Small specimen, probably incomplete and abraded, U.S.N.M. No. 127609c. 11. Small specimen, probably complete, showing scattered apopores, paratype, U.S.N.M. No. 127609a. 12. Abraded fragment, probably of this species, showing part of apochete, U.S.N.M. No. 127609e.

1, 2, 4, and 5–7 are natural size; 8–12 are twice natural size; and 3 is five times natural size.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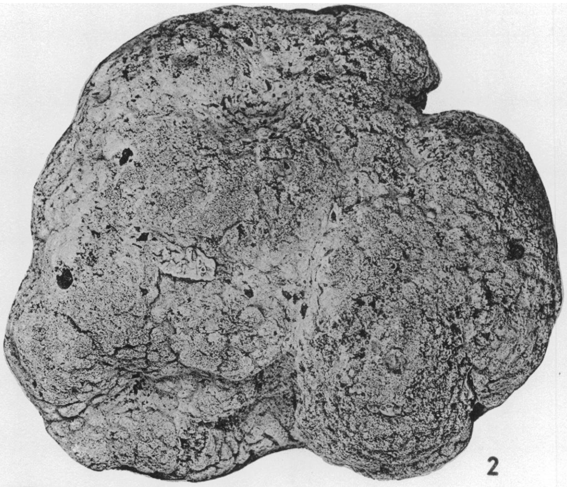
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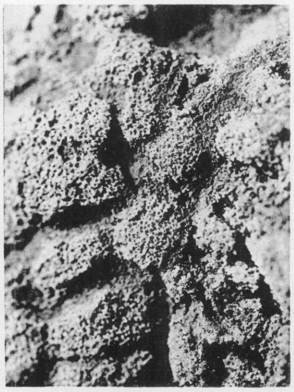
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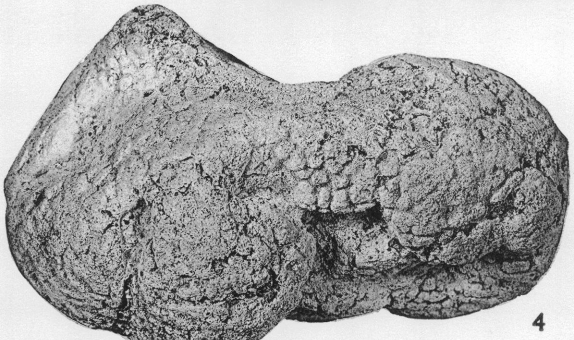
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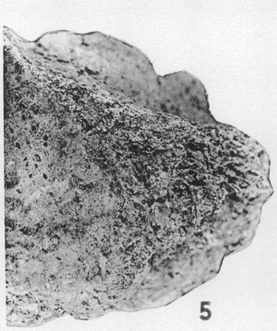
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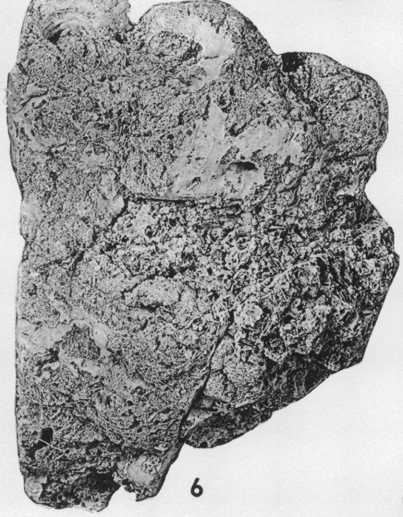
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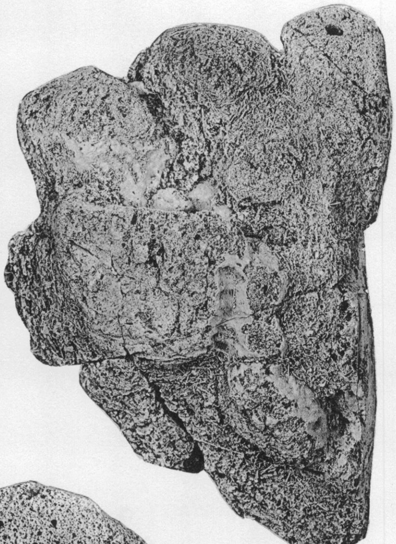
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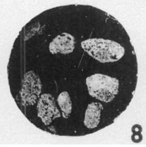
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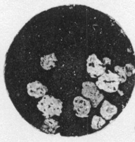
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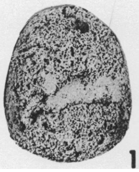
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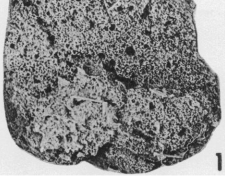
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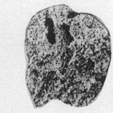
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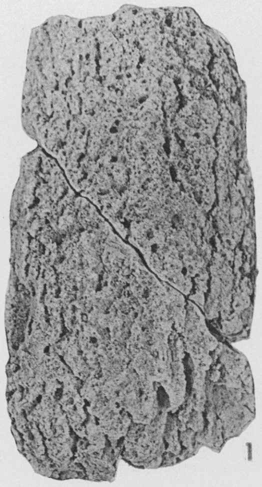
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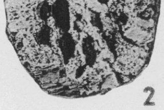
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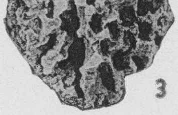
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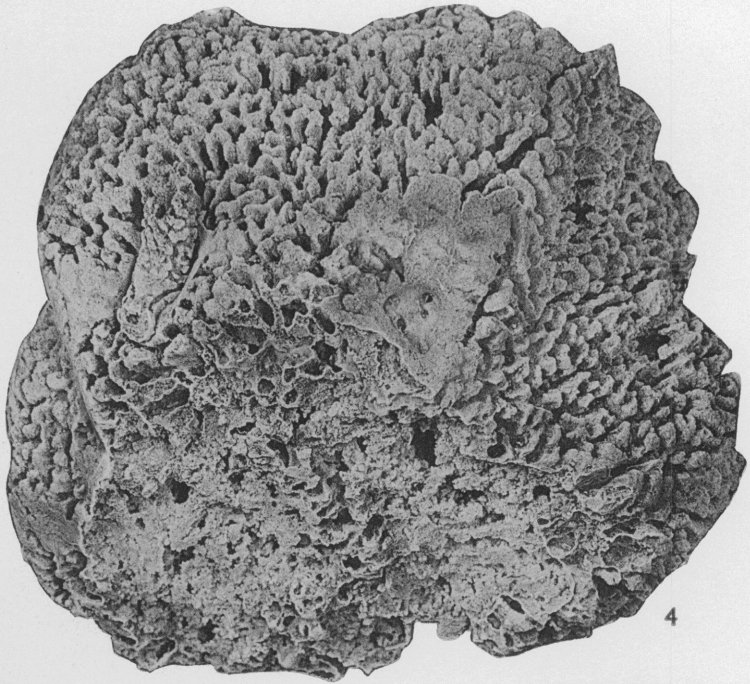
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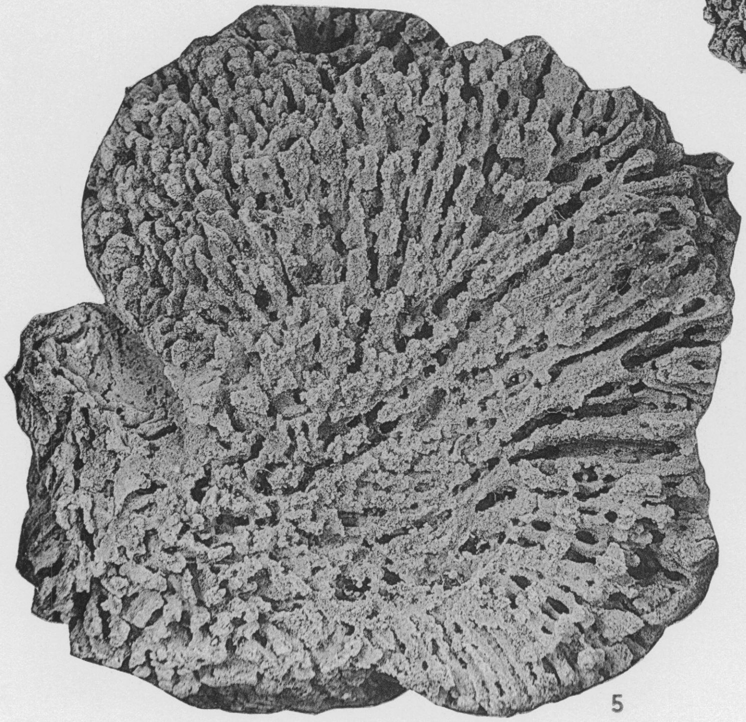
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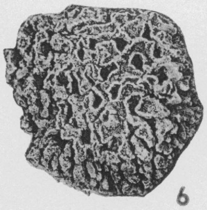
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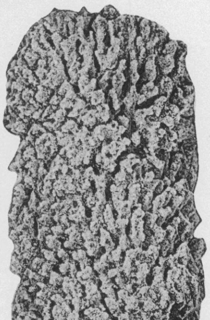
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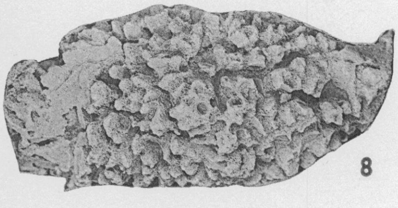
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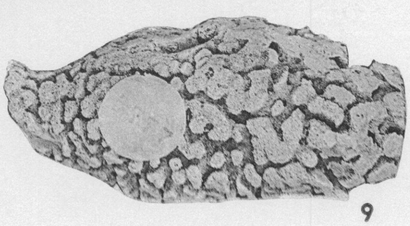
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PLATE 16

1–3. *Jereina cylindrica* Finks, new species. 1. Side view of incomplete individual referred with some doubt to this species, P.U. No. 78883, from P.U. 77, Bone Spring limestone. 2. Broken end of same specimen showing axial apochetes. 3. Opposite end of same specimen.

4–9. *Actinocoelia maeandrina* Finks, new species. 4. Side of holotype showing a small cylindrical individual partly enclosed at upper left, U.S.N.M. No. 127611, from U.S.N.M. 749, San Andres formation. 5. Opposite side of same specimen, probably broken, showing a longitudinal section. 6. Broken end of a cylindrical specimen showing cross section of sponge, paratype, P.U. No. 78882, from P.U. 20gh, Bone Spring limestone. 7. Side of same specimen. 8. Side of cylindrical specimen, nearly complete, paratype, U.S.N.M. No. 127612, from U.S.G.S. 5777, Bone Spring limestone. 9. Opposite side of same specimen.

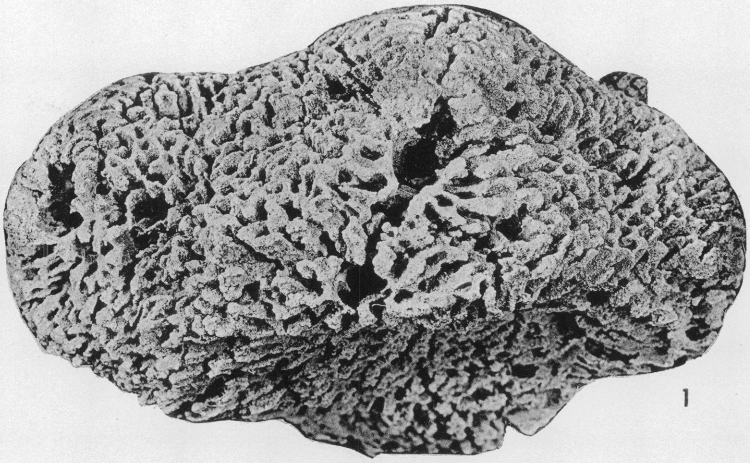
All natural size.

PLATE 17

1, 2. *Actinocoelia maeandrina* Finks, new species. 1. Edge of holotype (see other figures on preceding plate) showing oscules on what may have been top of sponge, U.S.N.M. No. 127611, from U.S.N.M. 749, San Andres formation. 2. Magnified view of broken surface of same specimen showing spicular net.

3–7. ?*Actinocoelia verrucosa* Finks, new species. 3. Paratype, showing characteristic conical protuberances, U.S.N.M. No. 127614a, from U.S.N.M. 702, Leonard formation. 4. Reduced view of upper surface of holotype showing clusters of apopores with associated radial grooves, U.S.N.M. No. 127613, from U.S.N.M. 703b, Leonard formation. 5. View of apopore cluster, same specimen. 6. Magnified profile view of the flattened trabeculae visible just above the apopore cluster in the preceding figure, showing the parallel monaxons composing them. 7. Magnified view of surface adjacent to that shown in 6, showing spicules in floor of surface groove.

1, 3, and 5 are natural size; 4 is one-half natural size; and 2, 6, and 7 are five times natural size.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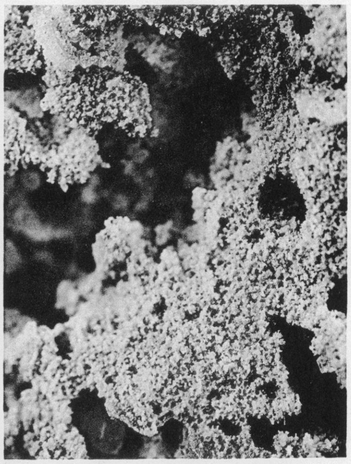
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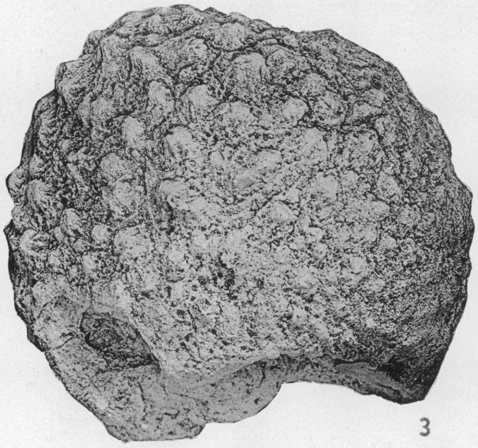
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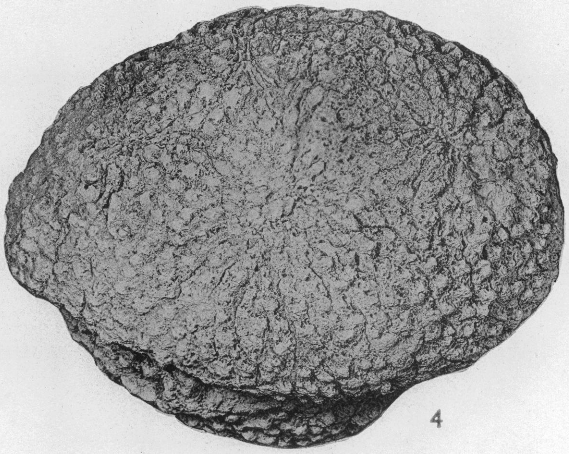
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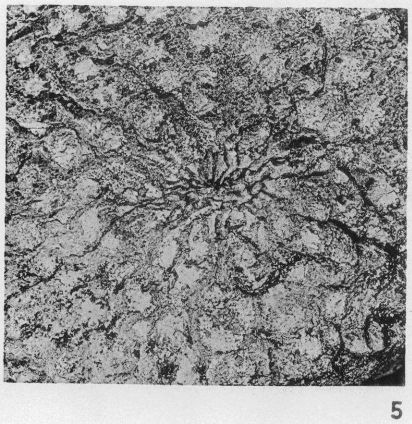
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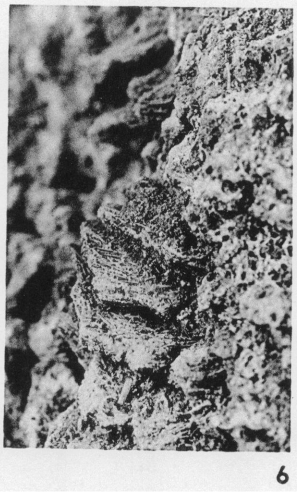
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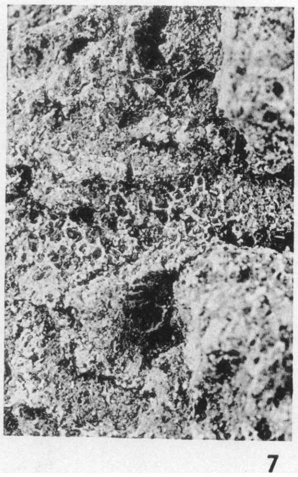
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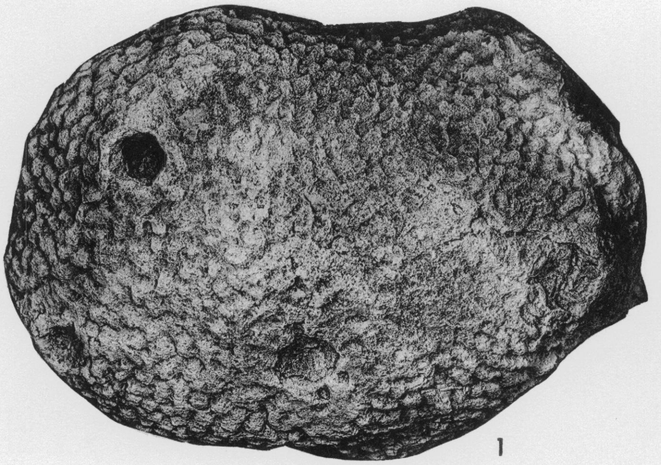

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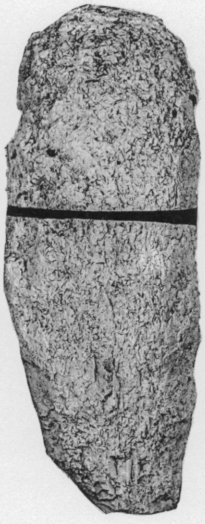

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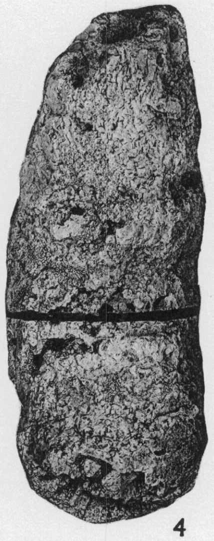

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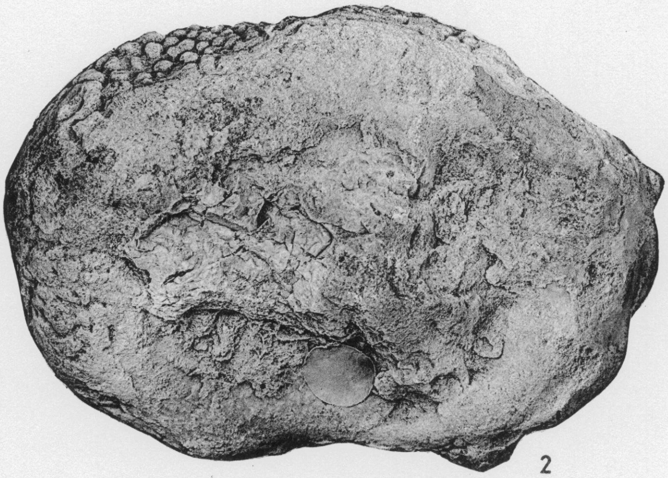

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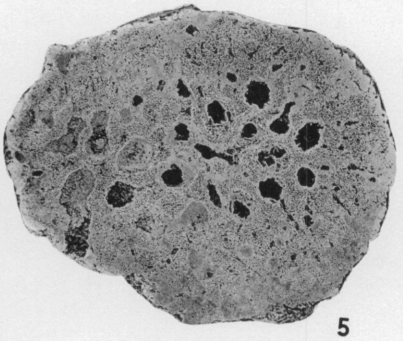

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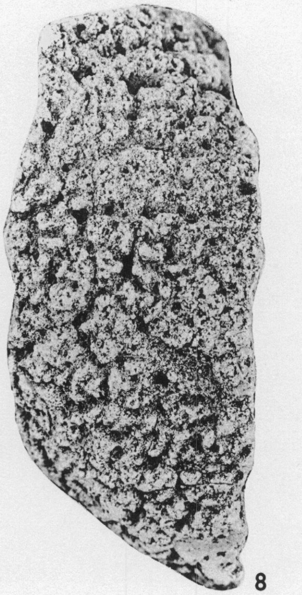

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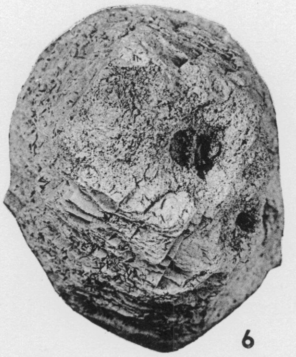

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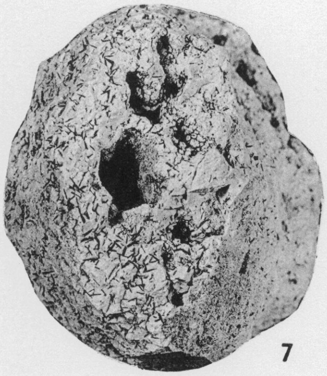

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PLATE 18

1, 2. *?Actinocoelia verrucosa* Finks, new species. 1. Top surface of specimen assigned with some doubt to this species, showing large oscules, U.S.N.M. No. 127615a, from U.S.N.M. 703b, Leonard formation. 2. Imperforate basal surface of same specimen; the angularly fractured material in the center is the matrix.

3–8. *Jereina cylindrica* Finks, new species. 3. Reduced view of convex side of holotype; the fine straight lines are molds of unidentified, tabular crystals embedded in the chertified surface of the sponge, P.U. No. 78875, from P.U. 20g, Bone Spring limestone. 4. Opposite concave side of same specimen showing small, circular oscules scattered over surface. 5. Cross section of same specimen showing axial apochetes; at lower left one of them communicates with an oscule on surface of sponge. 6. End of same specimen showing terminal openings of axial apochetes. 7. Opposite end of same specimen. 8. Outer surface of fragment of cylindrical sponge showing pores and grooves; the axis of the sponge runs left to right, paratype, U.S.N.M. No. 127616, from U.S.G.S. 14461, Bone Spring limestone.

All natural size, except 3 and 4, which are one-half natural size, and 8, which is twice natural size.

PLATE 19

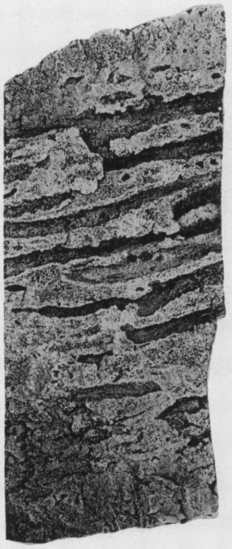
1, 2. *Jereina cylindrica* Finks, new species. 1. Median longitudinal section of part of cylindrical sponge, axis running left to right, showing axial apochetes, paratype, P.U. No. 78876, from P.U. 20g, Bone Spring limestone. 2. Cross section of same specimen.

3–7. *Jereina ramosa* Finks, new species. 3. Cross section showing canals, probably apochetes at center, paratype, U.S.N.M. No. 127619, from U.S.G.S. 5777, Bone Spring limestone. 4. Exterior of same specimen. 5. Side view of holotype, with end of branch at top, the bottom end broken, showing a cluster of apopores, U.S.N.M. No. 127617, from U.S.N.M. 707e, Word formation. 6. Oblique view of top end of same specimen. 7. Broken end of same specimen showing cross section of interior.

8–10. Etched block from base of Bone Spring limestone showing a typical marginal basin-facies assemblage, more or less in place. All the sponges from P.U. 80c described in this paper were removed from this small block. The block, as shown here, bears P.U. No. 78862, but individual sponges taken from it are numbered separately. Letters on the plate identify individual sponges as follows: (A) *Dactylites micropora* Finks, new species; (B) *Haplistion aeluroglossa* Finks, new species; (C) unidentified chiastoclonellid; (D) cf. *Actinocoelia maeandrina* Finks, new species; (E) unidentified possible anthracosyconid, cf. *Collatipora* sp.; (F) *Pileolites baccatus* Finks, new species (three adjacent individuals); (G) another specimen of *Haplistion aeluroglossa* Finks, new species. 8. Side of block showing large monaxon fragments at lower left, aligned parallel to bedding plane. Specimen F is lying on its side, top towards the left. Note specimen D molded to surface of specimen B. 9. Oblique view of opposite side of block. The second specimen from top under F is *Pileolites baccatus* with base facing upward. The holotype of *Haplistion aeluroglossa* Finks, new species, illustrated on plate 27, figures 1 and 2, was originally located immediately above specimen G. The holotype of *Dactylites micropora* Finks, new species, illustrated on plate 24, figures 1–5, was originally located in front of specimens C and D, lying on its side, with its upper end facing left end of block. 10. Top of block showing scattered fragments of stout monaxons which, before preparation, filled most of the space between the sponges; the side shown in 8 is at bottom; that in 9, at top.

11. Magnified top view of dichotetraene ornamented with annular ridges, P.U. No. 78905, from P.U. 80c, Bone Spring limestone.

All are natural size except 11, which is 10 times natural size.



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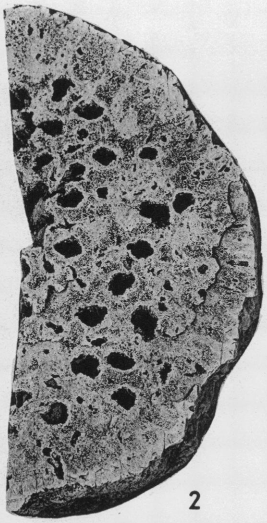

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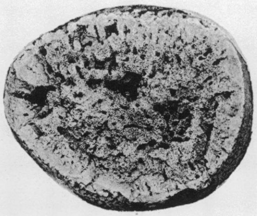

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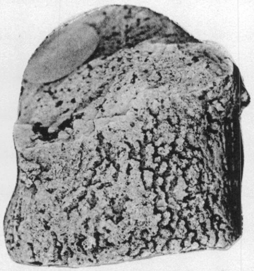

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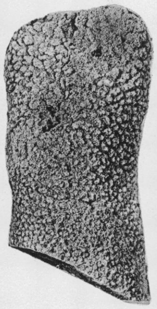

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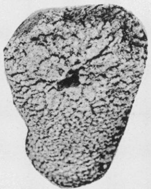

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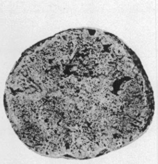

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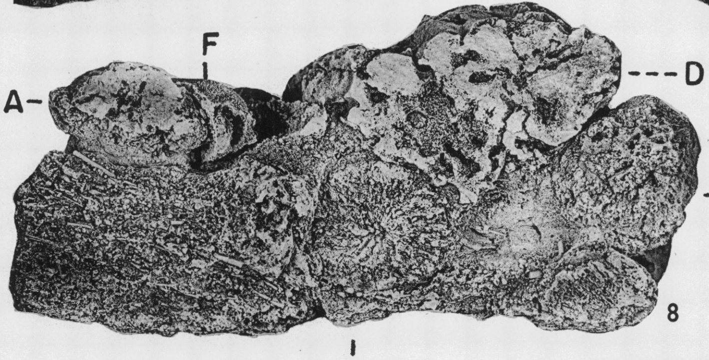

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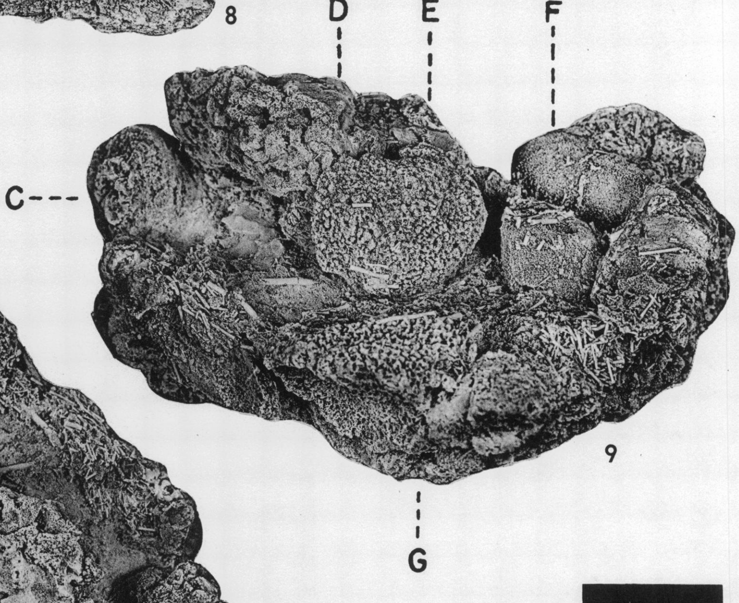

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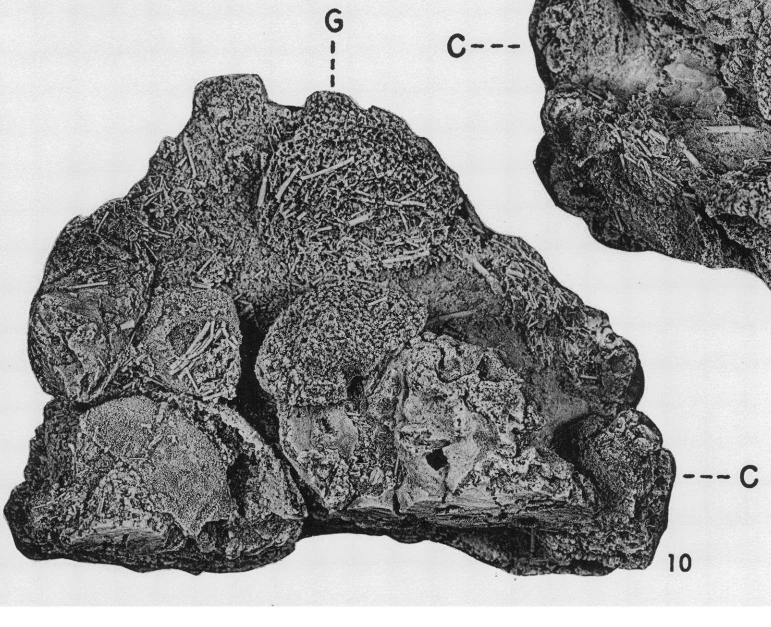

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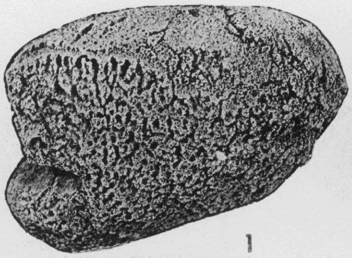
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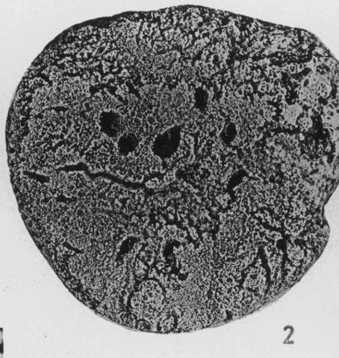
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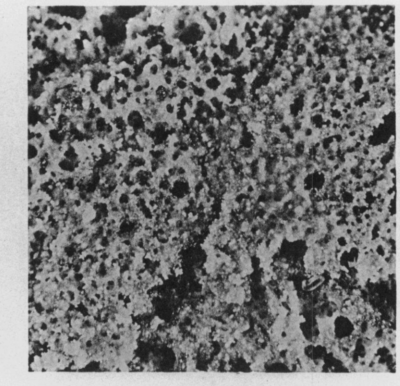
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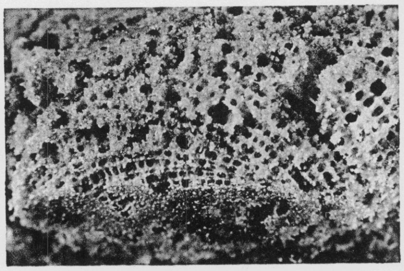
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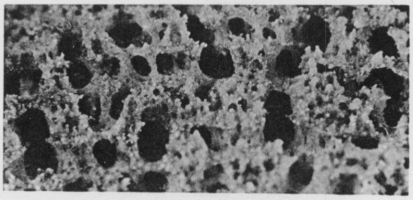
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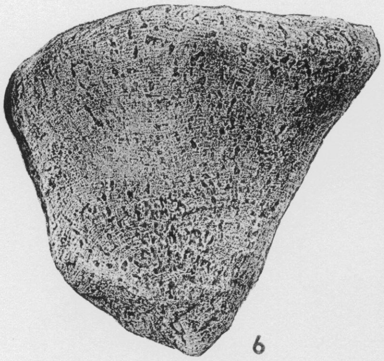
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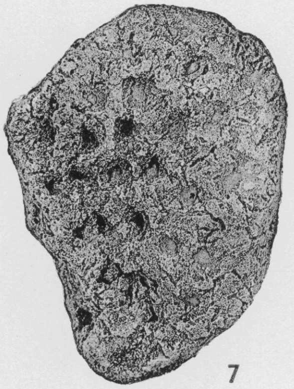
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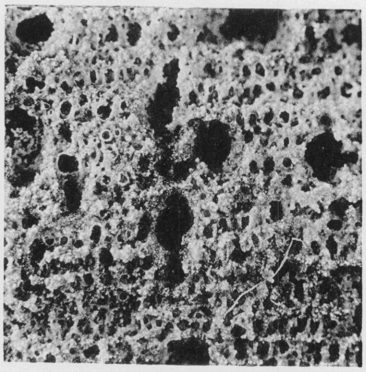
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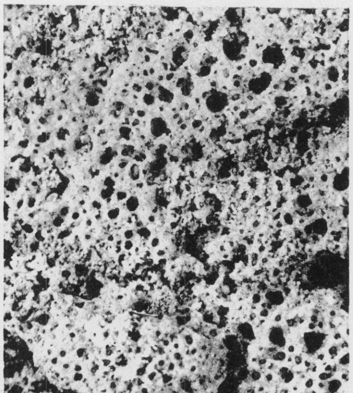
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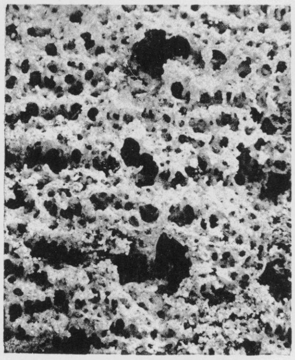
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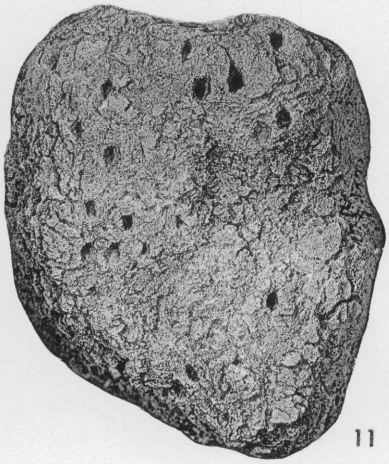
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PLATE 20

1–5. *Anthracosycon ficus* Girty. 1. Enlarged side view of holotype showing prosopores; the slit at lower left is the mold of a shell which served as the original attachment, U.S.N.M. No. 118127, from U.S.G.S. 2920 green, Bone Spring limestone. 2. Enlarged top view of holotype showing oscules and surface canals. 3. Magnified view of part of top surface of holotype, formed by fused cladomes of spicules in the uppermost layer of sponge. 4. Magnified side view of spicular net of holotype immediately above basal attachment surface, which is the lower surface of the slit shown in 1; the horizontal layers of tetraclones are clearly visible; the spicules are not bundled here, that is, adjacent skeletal pores are separated by a single rhabdome. 5. Magnified side view of spicular net of holotype near top of sponge, showing bundling of rhabdomes.

6–11. *Anthracosycon regulare* (King). 6. Side of holotype, K.U. No. 74147, from U.S.N.M. 707q, Leonard formation. 7. Top of holotype showing oscules and surface canals. 8. Magnified side view of spicular net of holotype; the spicules are mostly not bundled. 9. Magnified view of top surface of topotype, showing a surface canal at lower left; most of the surface is formed by the fused cladomes of spicules in the topmost layer of the sponge, but there are some spicules with rhabdomes in the plane of the surface, U.S.N.M. No. 127620a, from U.S.N.M. 707q, Leonard formation. 10. Magnified side view of spicular net of same specimen showing some bundling of rhabdomes. 11. Complete top surface of same specimen showing oscules.

6, 7, and 11 are natural size; 1 and 2 are twice natural size; and 3–5 and 8–10 are 10 times natural size.

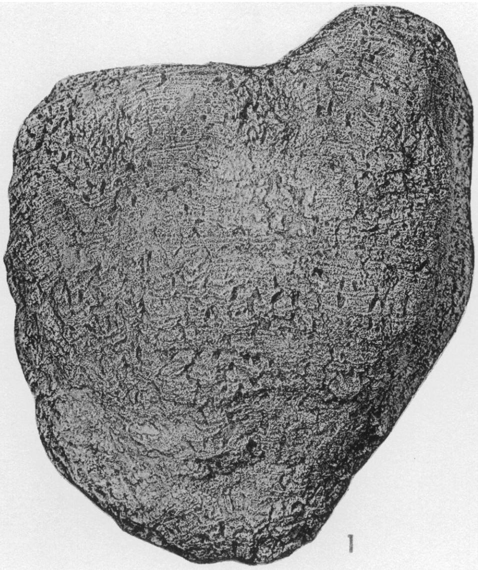
PLATE 21

1, 2. *Anthracosycon regulare* (King). 1. Side of topotype illustrated on preceding plate, U.S.N.M. No. 127620a, from U.S.N.M. 707q, Leonard formation. 2. Top of large specimen, A.M.N.H. No. 28093, from A.M.N.H. 500, Leonard formation.

3–5. *?Anthracosycon auriforme* Finks, new species. 3. Enlarged view of concave excurrent side of holotope showing two sizes of pores, U.S.N.M. No. 127621, from U.S.G.S. 6938, Bone Spring limestone. 4. Enlarged view of convex incurrent side of same specimen showing prosopores and, where smooth surface layer is missing, the parallel layers of spicules. 5. Enlarged view of part of top edge of same specimen showing surface canals; the excurrent surface is above, the incurrent surface below.

6. Unidentified sponge, cf. *Collatipora discreta* Finks, new species, enlarged top view, U.S.N.M. No. 127624, from U.S.N.M. 706, Word formation.

1 and 2 are natural size, and 3–6 are twice natural size.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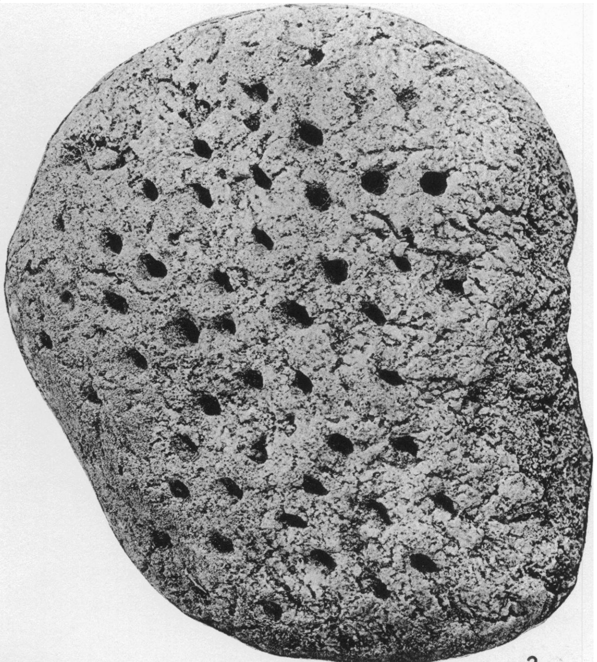
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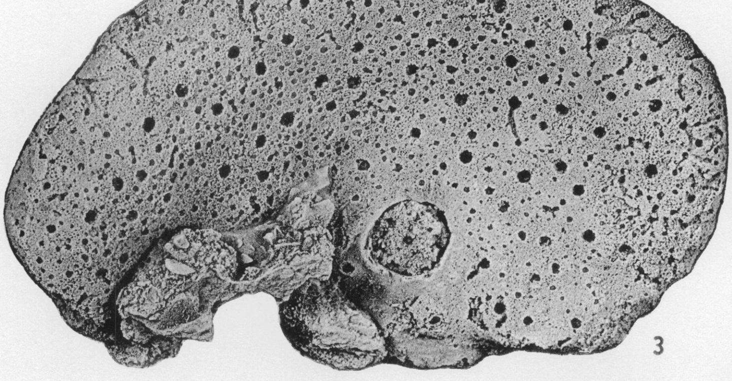
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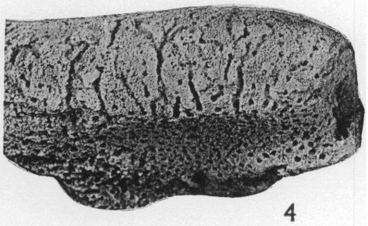
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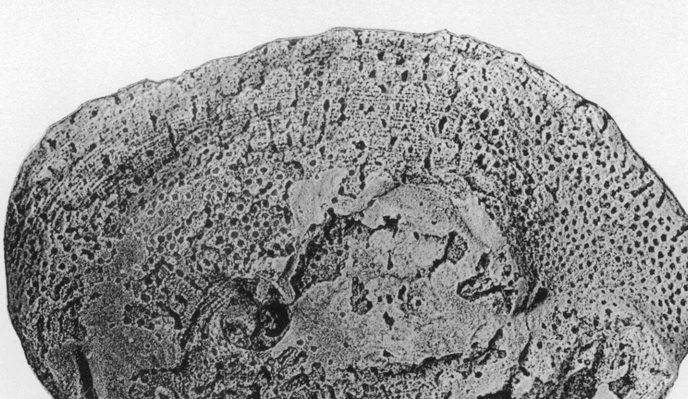
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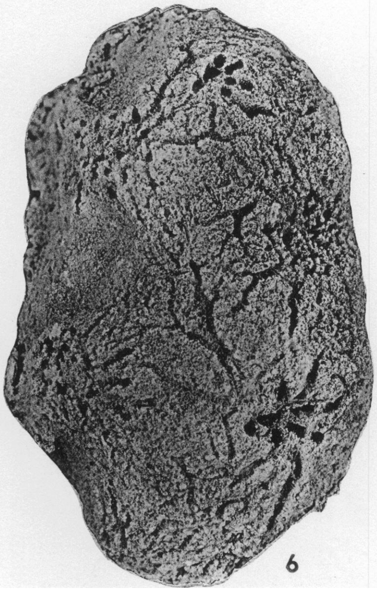
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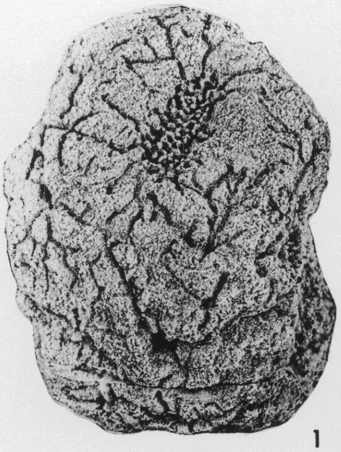
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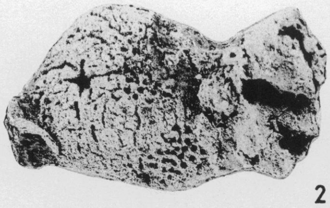
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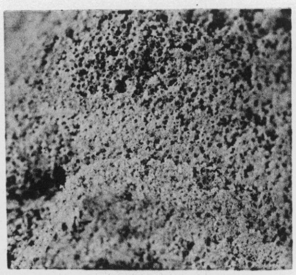
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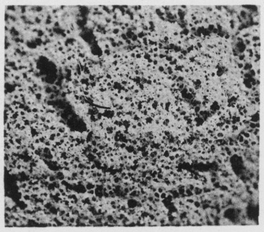
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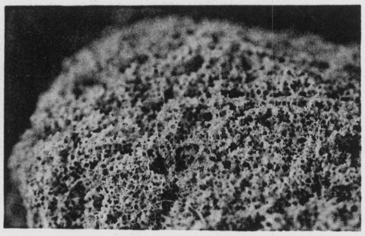
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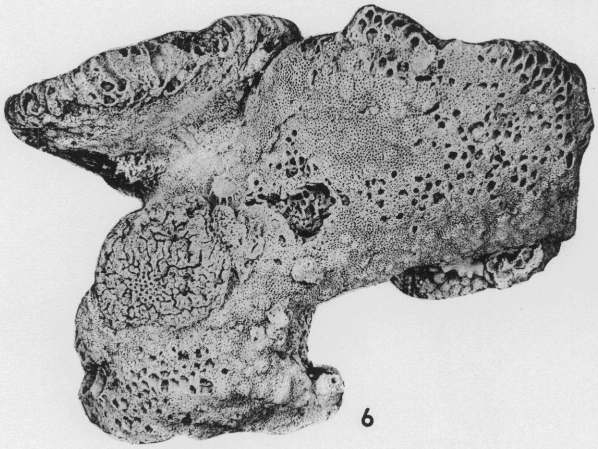
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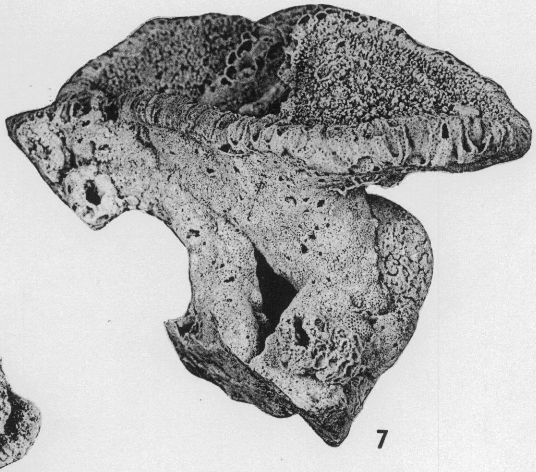
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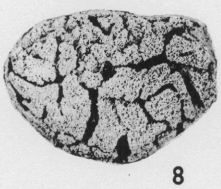
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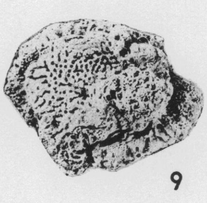
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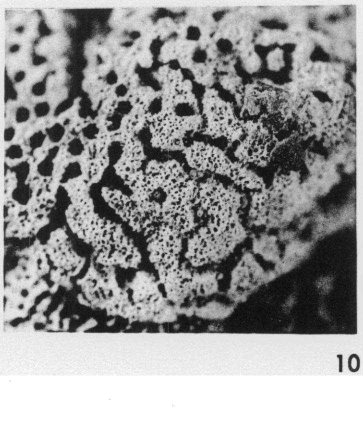
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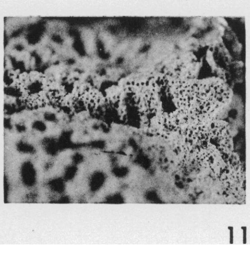
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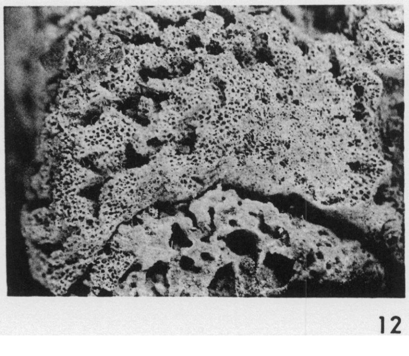
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PLATE 22

1–5. *Collatipora discreta* Finks, new species. 1. Enlarged view of paratype showing surface canals, pore cluster above, and oscule below, U.S.N.M. No. 127622, from Y.P.M. 37, Leonard formation. 2. Holotype showing two pore clusters in middle and an oscule at left, A.M.N.H. No. 28094, from A.M.N.H. 389, Bell Canyon formation. 3. Magnified view of nearly imperforate surface covering portions of holotype. 4. Magnified view of ordinary surface of holotype showing pores and surface grooves. 5. Magnified view of section perpendicular to surface of holotype, showing horizontal spicule layers.

6, 7. *Collatipora delicata* Finks, new species. 6. Hemispherical individual growing, lower left, on the side of a specimen of *Guadalupia zitteliana* Girty, showing a pore cluster and an oscule, paratype, U.S.N.M. No. 127625, from U.S.N.M. 728, Cherry Canyon formation. 7. View of left side of 6; *Collatipora* at right showing scattered pores not part of cluster.

8. *?Collatipora* sp. cf. *C. delicata* Finks, new species. Enlarged view of a small specimen overgrowing the end of a bryozoan colony, U.S.N.M. 127628c, from U.S.N.M. 705a, Leonard formation.

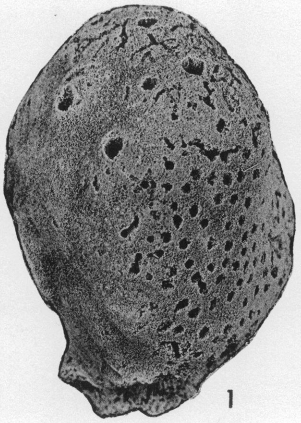
9–12. *Collatipora delicata* Finks, new species. 9. Holotype growing in a cup-shaped specimen of *Guadalupia zitteliana* Girty, A.M.N.H. No. 28095, from A.M.N.H. 512, Cherry Canyon formation. 10. Magnified view of top surface of holotype showing spicular net. 11. Magnified view of section perpendicular to surface of holotype, showing horizontal layers of spicules. 12. Magnified view of imperforate part of surface of holotype, where sponge was in contact with part of *Guadalupia* once continuous with broken surface at bottom.

2, 6, 7, and 9 are natural size; 1 is twice natural size; and 3–5 and 10–12 are five times natural size.

PLATE 23

?*Collatipora pyriformis* Finks, new species. 1. Enlarged side view of holotype showing restriction of pores to one side of sponge; the pedunculate base is visible below and the lipped oscules are visible at top; if the pores at right are incurrent, the sponge may have grown in a current flowing from that direction, U.S.N.M. No. 127629, from U.S.N.M. 703c, Word formation. 2. Enlarged view of side seen at right in preceding figure; an oscule on a slight elevation is in the center; the basal peduncle is at bottom. 3. Enlarged view of top of holotype showing oscules and surface canals; the side shown in preceding figure is at left. 4. Enlarged view of base of holotype showing broken base of peduncle. 5. Enlarged view of imperforate side of holotype showing basal peduncle at top and a secondary point of attachment, also broken, in center. 6. Magnified view of broken end of peduncle of holotype showing concentric layers of unbundled spicules at top. 7. Magnified view of imperforate surface of holotype showing cladomes of individual spicules. 8. Magnified view of pore-bearing surface of holotype showing large pores and skeletal pores. 9. Magnified view of vertical section of paratype, parallel to horizontal, possibly incurrent, canals, showing strongly bundled spicules, including rhizoclone-like forms, curving about pores in canal walls, U.S.N.M. No. 127630a, from U.S.N.M. 703c, Word formation. 10. Magnified view of top of spicule layer of same sponge. 11. Magnified view of vertical section of same sponge, normal to horizontal canals shown in 9, showing strong bundling of spicules. 12. View of pore-bearing surface of fragmentary specimen, equivalent to that shown in 2, paratype, A.M.N.H. No. 28096, from A.M.N.H. 503, Word formation. 13. Section of same specimen, normal to surface, showing radial canals leading to pores.

12 and 13 are natural size; 1–5 are twice natural size; and 6–11 are five times natural size.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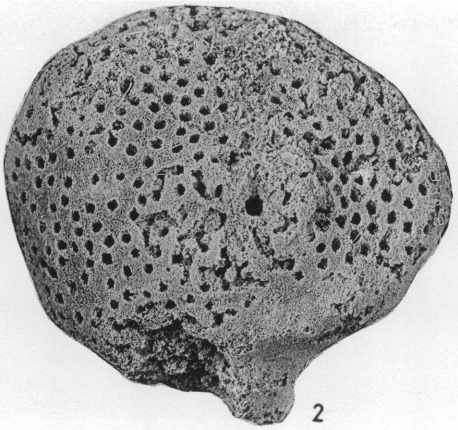
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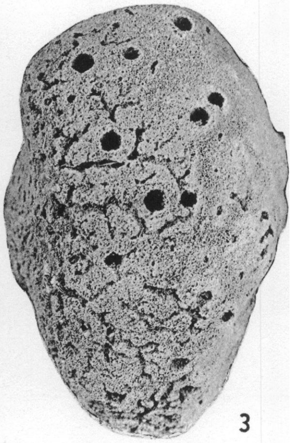
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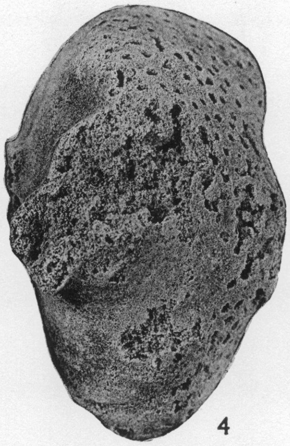
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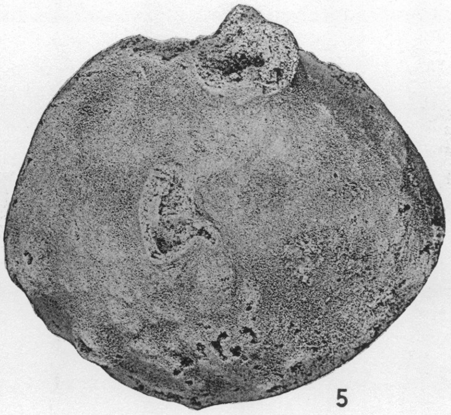
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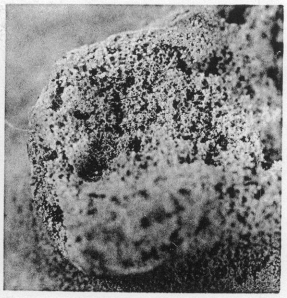
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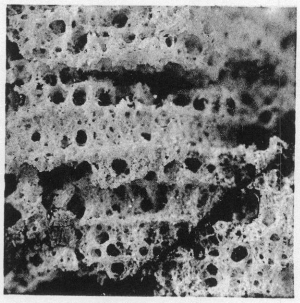
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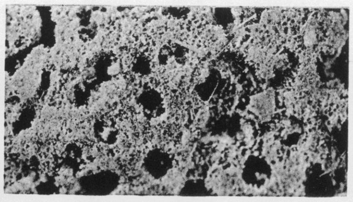
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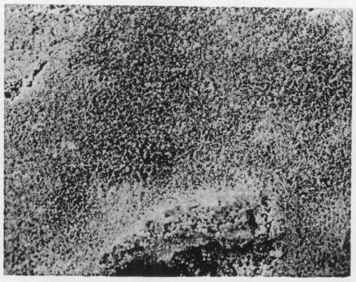
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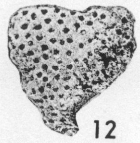
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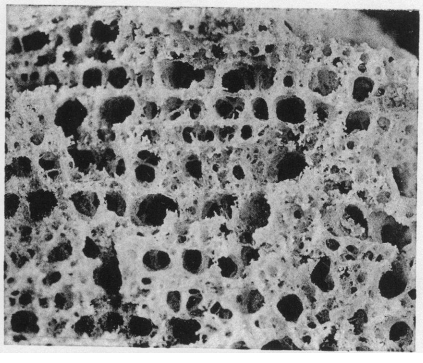
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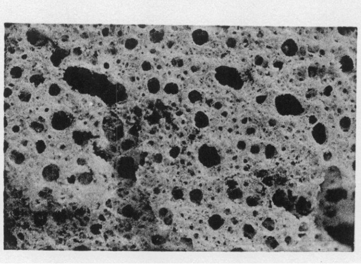
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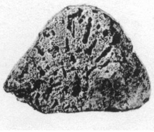
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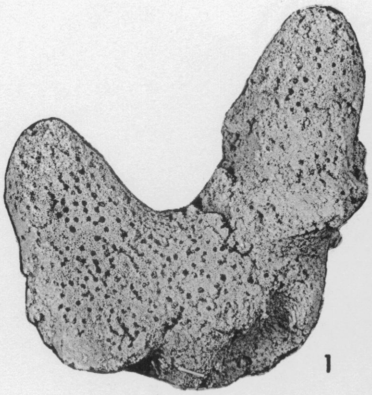
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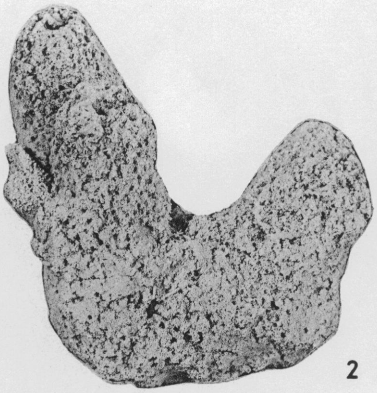
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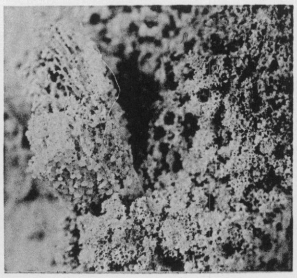
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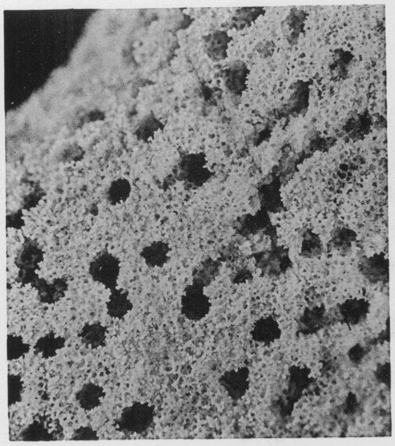
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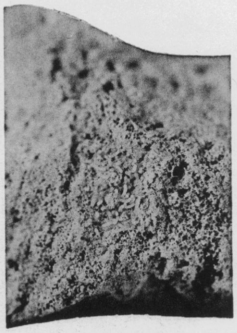
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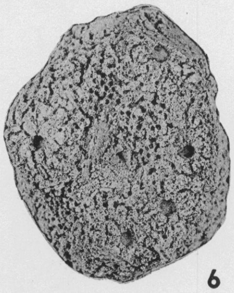
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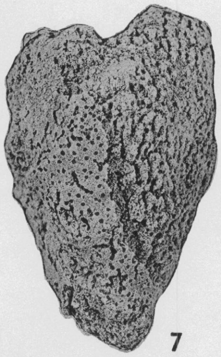
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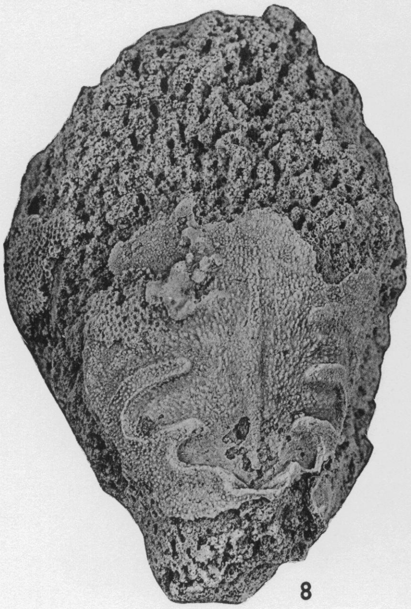
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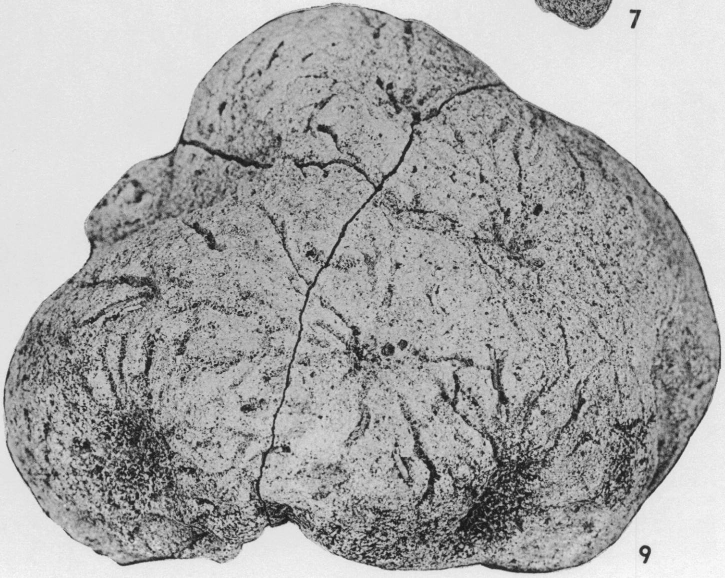
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PLATE 24

1–5. *Dactylites micropora* Finks, new species. 1. Enlarged side view of holotype showing prospores, P.U. No. 78881, from P.U. 80c, Bone Spring limestone. 2. Other side of holotype showing terminal oscules on two branches at left. 3. Magnified view of holotype showing *Pileolites baccatus* Finks, new species, overgrown at left. 4. Magnified view of surface of holotype showing prosopores and skeletal pores. 5. Magnified view of groove on base of holotype lined with small, curved strongyles belonging to an unknown sponge.

6–8. ?*Dactylites subdigitatus* Finks, new species. 6. Top of specimen showing oscules at the summits of protuberances, P.U. No. 78880, from P.U. 3e, Bone Spring limestone. 7. Side of same specimen showing original smooth surface, with prosopores, preserved at left. 8. Enlarged view of other side of same specimen showing an epoecious leptodid brachiopod, as well as patches of a bryozoan at left; the horizontal spicule layers are visible on the decorticated surface near the top.

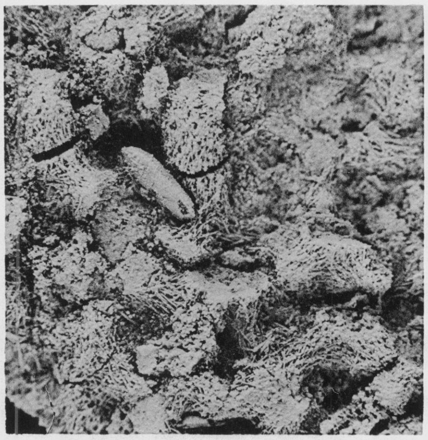
9. Tetracladine lithistid, cf. *Collatipora discreta* Finks, new species. Enlarged view, U.S.N.M. 127623, from U.S.N.M. 702, Leonard formation.

6 and 7 are natural size; 1, 2, 8, and 9 are twice natural size; and 3–5 are five times natural size.

PLATE 25

Haplistion sphaericum Finks, new species. 1. Magnified view of surface of paratype showing trabeculae composed of interlaced monaxons, U.S.N.M. No. 127633a, from U.S.N.M. 518q, Magdalena formation. 2. Top surface of same specimen showing projecting ends of trabeculae. 3. Side view of same specimen. 4. Magnified view of surface of holotype showing numerous strongyles lodged between trabeculae, U.S.N.M. No. 127632, from U.S.N.M. 518q, Magdalena formation. 5. Magnified view of radial polished section of paratype showing trabeculae, light colored, made of subparallel monaxons, U.S.N.M. No. 127633a, from U.S.N.M. 518q, Magdalena formation. 6. Section of holotype showing radial arrangement of trabeculae, some of which are preserved as hollow tubes, U.S.N.M. No. 127632, from U.S.N.M. 518q, Magdalena formation.

2, 3, and 6 are natural size, and 1, 4, and 5 are 10 times natural size.



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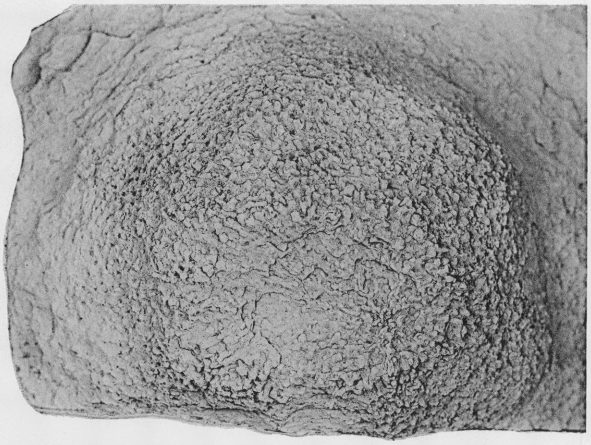

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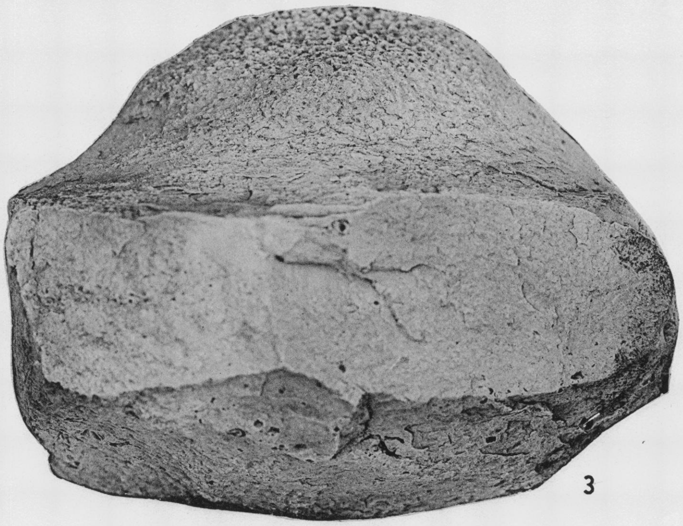

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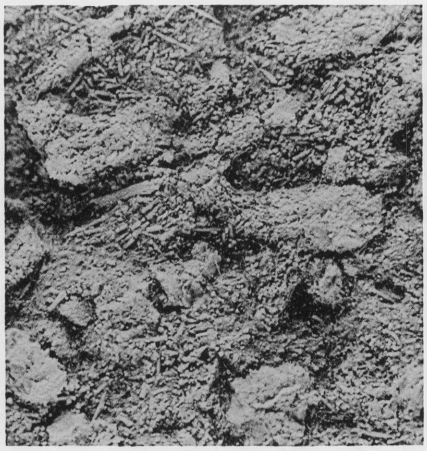

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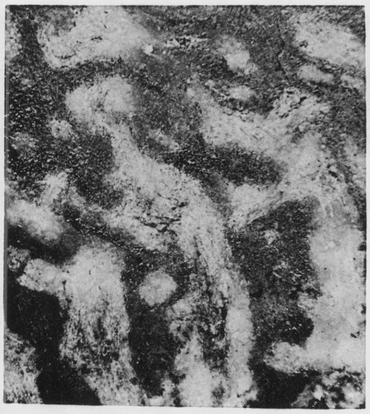

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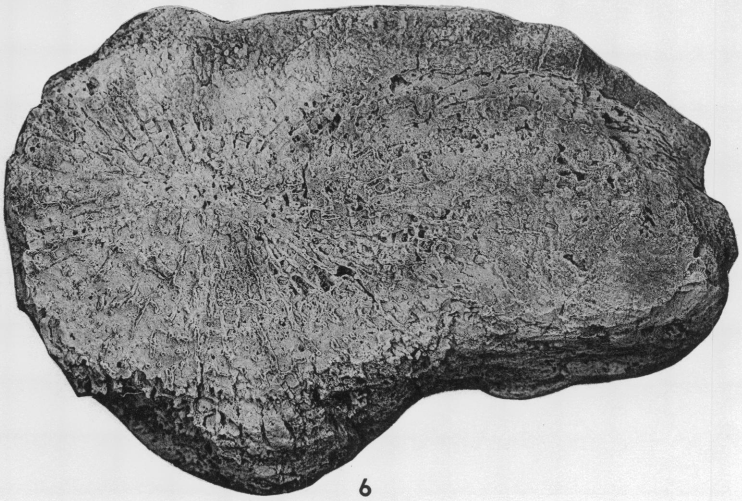

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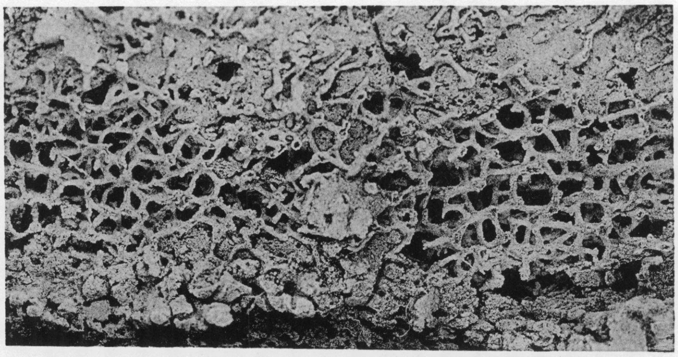
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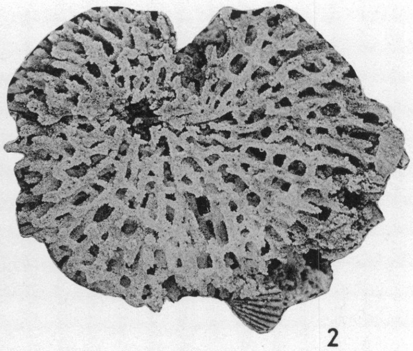
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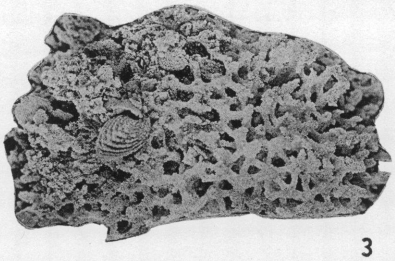
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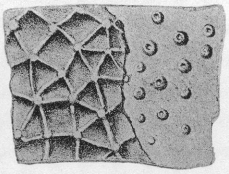
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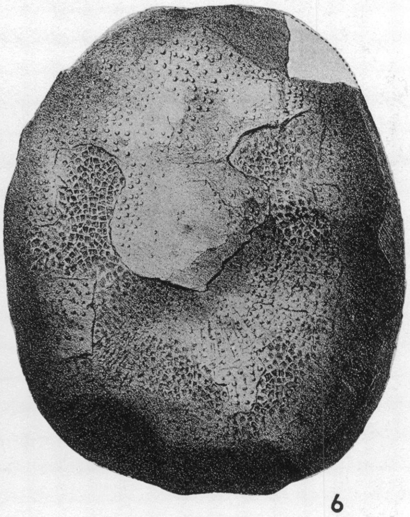
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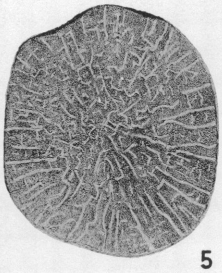
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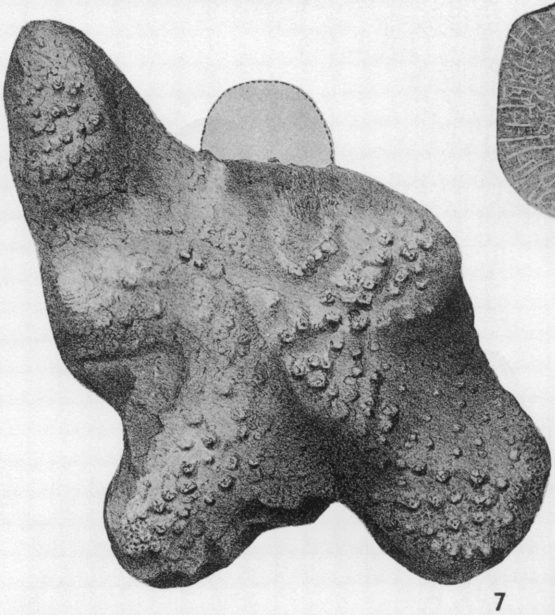
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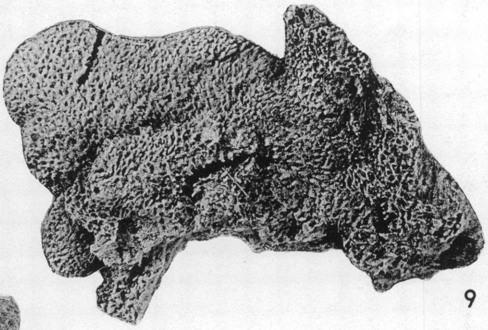
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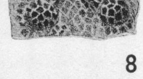
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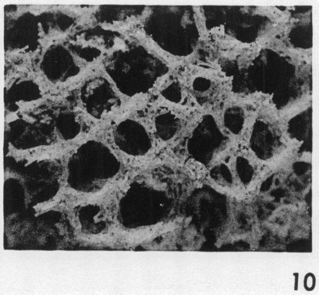
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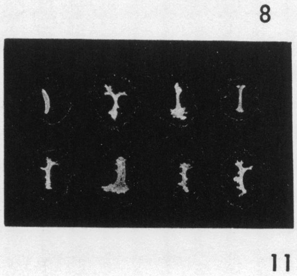
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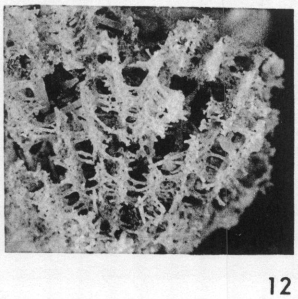
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PLATE 26

1–3. *Haplistion sphaericum* Finks, new species. 1. Enlarged view of trabeculae of holotype, partly etched from matrix; they are preserved here partly as tubular structures, U.S.N.M. No. 127632, from U.S.N.M. 518q, Magdalena formation. 2. Enlarged sagittal section of juvenile, paratype, U.S.N.M. No. 127633b, from U.S.N.M. 518q, Magdalena formation. 3. Enlarged view of surface of same specimen showing pattern of trabeculae and small brachiopod overgrown by sponge.

4. *Pemmatites arcticus* Dunikowski. Drawing (from Dunikowski, 1884, pl. 2, fig. 3) of part of surface showing trabeculae; from Axel's Island, Spitzbergen, *Productus* chert. Compare with 3 of this plate, which is to same scale.

5. *Pemmatites arcticus* var. *macropora* Dunikowski. Drawing (from Dunikowski, 1884, pl. 2, fig. 5) of median polished section showing trabeculae; from Axel's Island, Spitzbergen, *Productus* chert.

6. *Pemmatites arcticus* Dunikowski. Drawing (from Dunikowski, 1884, pl. 2, fig. 4) of specimen showing trabecular mesh; from Axel's Island, Spitzbergen, *Productus* chert.

7, 8. *Pemmatites verrucosus* Dunikowski. 7. Drawing (from Dunikowski, 1884, pl. 1, fig. 8) of what was probably the sole specimen, showing lobate form and wart-like protuberances on surface, which are not the same as the projecting ends of trabeculae seen in 6; from Axel's Island, Spitzbergen, *Productus* chert. Drawing (from Dunikowski, 1884, pl. 1, fig. 11) of part of surface of same specimen enlarged to show wart-like protuberances and trabecular mesh. Compare with 9 of this plate, which is shown to same scale.

9–12. *Haplistion aeluroglossa* Finks, new species. 9. Compressed, lobate specimen showing oscule, which appears as small dark spot, at end of lobe at left center, paratype, A.M.N.H. No. 28097, from A.M.N.H. 503, Word formation. 10. Magnified view of surface of paratype showing trabecular net made of rhizoclones, P.U. No. 78865, from P.U. 80c, Bone Spring limestone. 11. Magnified view of isolated spicules from another specimen; at upper left is a strongyle and at upper right a dendroclone-like form; the rest are rhizoclones, the second from left, bottom row, showing two united; paratype, P.U. No. 78904b, from P.U. 80c, Bone Spring limestone. 12. Magnified view of radial section near apical end of another specimen, showing radial trabeculae connected merely by single spicules, some of dendroclone-like form, paratype, P.U. No. 78906, from P.U. 80c, Bone Spring limestone.

8 and 9 are natural size; 5–7 are one-half natural size; 1–4 are twice natural size; and 10–12 are 10 times natural size.

· PLATE 27

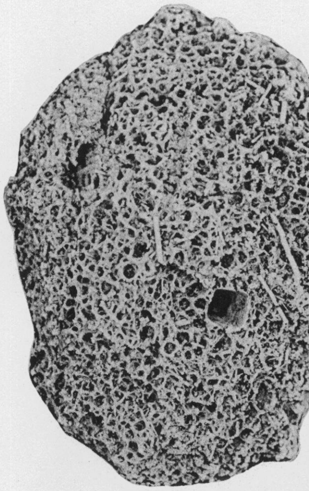
1,2. *Haplistion aeluroglossa* Finks, new species. 1. Enlarged view of top surface of holotype; the large square opening is a mold of *Conularia* sp. cf. *C. leonardensis* Finks, a second one is barely visible at the middle of the right edge; this is the specimen referred to as a "bun-shaped lithistid" in Finks (1955, p. 833, footnote); P.U. No. 78864, from P.U. 80c, Bone Spring limestone. 2. Magnified view of top surface of holotype showing spicules in trabeculae.

3. *Haplistion armstrongi* Young and Young. From Hinde (1888a, pl. 5, figs. 1, 1a, 1b). The holotype, from lower limestone series, lower Carboniferous, at Cunningham Baidland, Ayrshire, Scotland, is in center showing upper surface; on each side are views at different magnifications of another fragmentary specimen, from same formation at Law Quarry, Dalry, Ayrshire, Scotland. This is the genotypic species.

4. *Haplistion vermiculatum* (Carter). From Hinde (1888a, pl. 5, figs. 2, 2a). The holotype showing upper surface, at different magnifications, from lower limestone series, lower Carboniferous, at Cunningham Baidland, Ayrshire, Scotland.

5. *Haplistion skinneri* (King). Sagittal section of holotype showing arrangement of trabeculae, K.U. No. 74167, from U.S.N.M. 709, Leonard formation.

5 is natural size; 1 is twice natural size; 2 is 10 times natural size; the specimens in 3 are, from left to right, 40 times, twice, and 15 times, natural size, respectively; and those in 4 are, from top to bottom, twice and 20 times natural size, respectively.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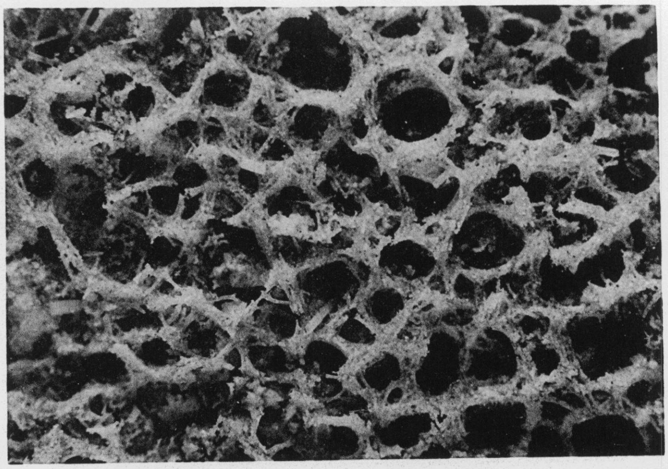
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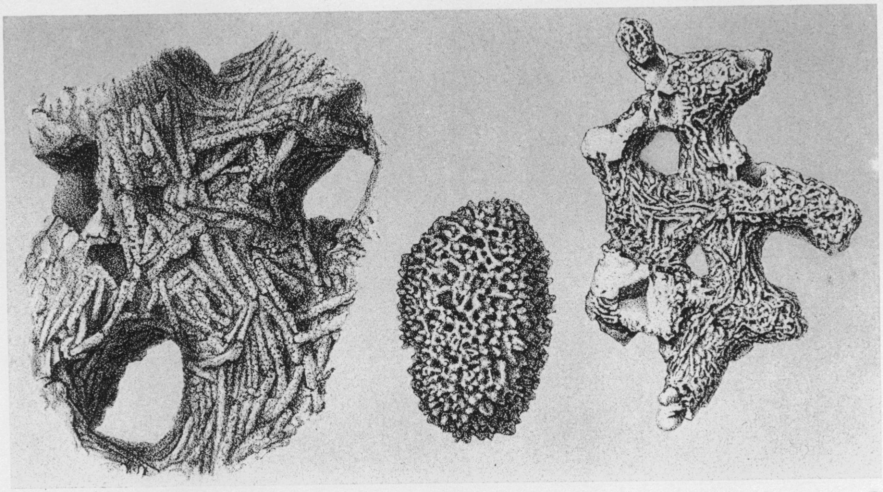
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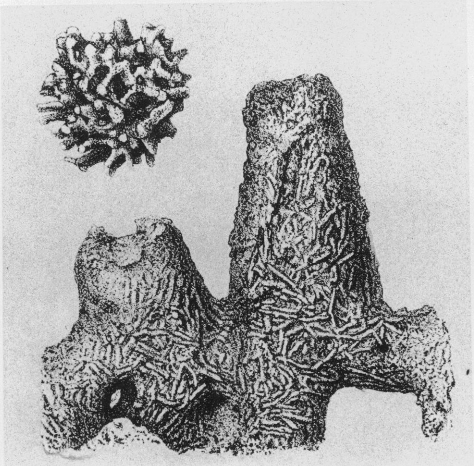
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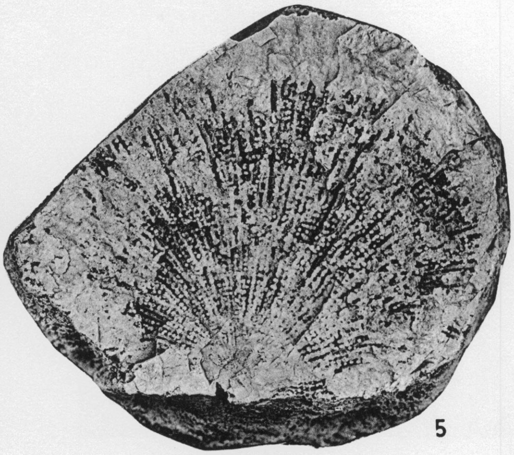
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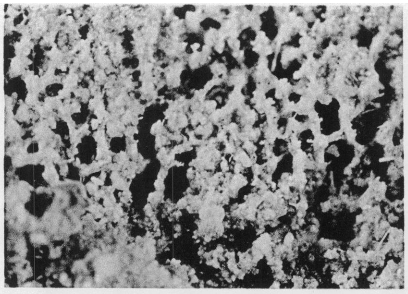
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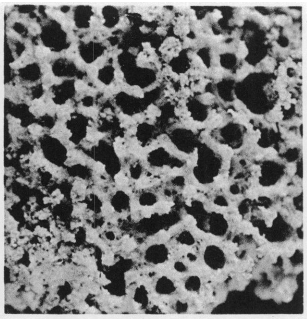
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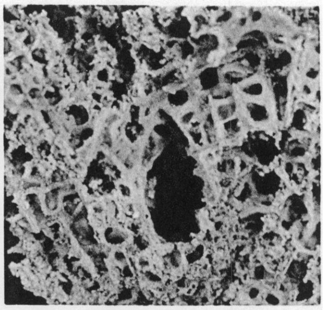
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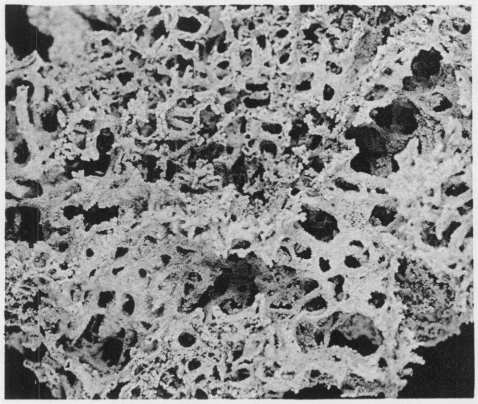
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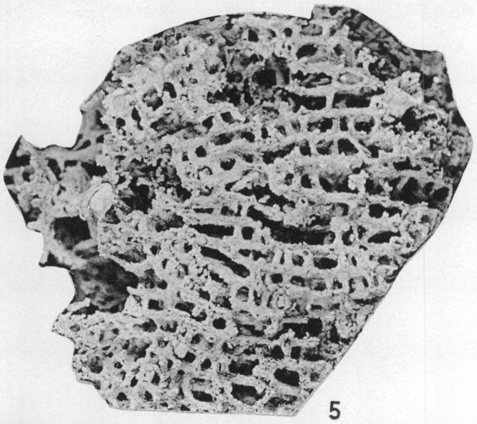
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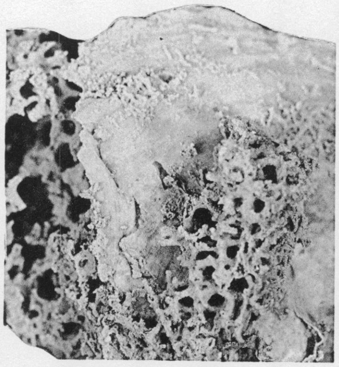
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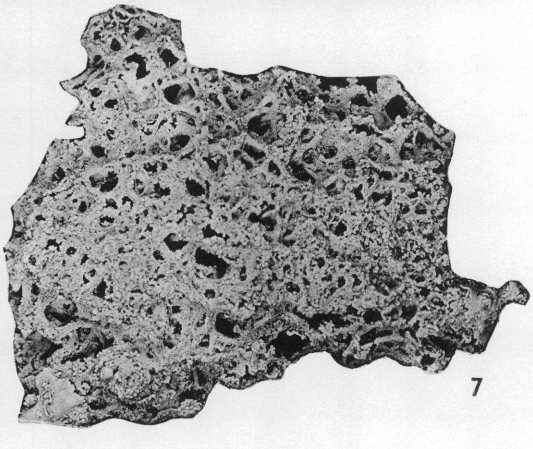
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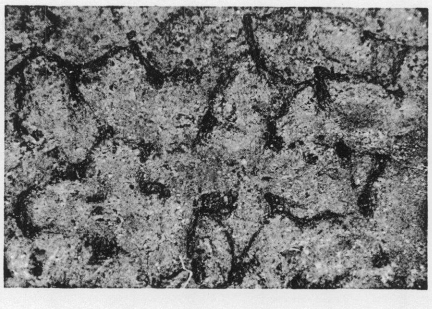
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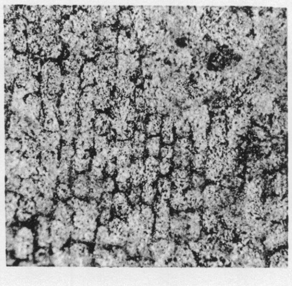
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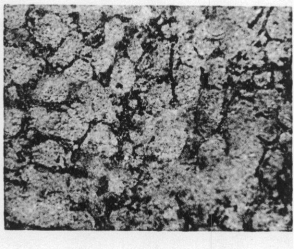
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PLATE 28

1, 2. *Haplistion skinneri* (King). 1. Magnified view of outer surface of holotype showing trabecular net, K.U. No. 74167, from U.S.N.M. 709, Leonard formation. 2. Magnified view of surface of inner layer concentric with outer surface, showing trabecular net; a spoke-like arrangement of spicules about a radial trabecula can be seen in center; topotype, U.S.N.M. No. 127636, from U.S.N.M. 709, Leonard formation.

3–7. *Haplistion megalochetus* Finks, new species. 3. Enlarged view of part of holotype showing large canal sectioned obliquely, U.S.N.M. No. 127637, from U.S.N.M. 701c, Wolfcamp formation. 4. Enlarged view of another part of holotype showing inner wall of large sinuous canal running from lower left to upper right. 5. Enlarged view of paratype fragment showing subparallel radial trabeculae, U.S.N.M. No. 127638b, from U.S.N.M. 701c, Wolfcamp formation. 6. Enlarged view of part of another paratype fragment showing a piece of large pelecypod shell overgrown by sponge, U.S.N.M. No. 127638a, from U.S.N.M. 701c, Wolfcamp formation. 7. Enlarged view of part of another paratype fragment showing what may have been the original outer surface of the sponge, formed by lateral expansion and fusion of horizontal trabeculae, U.S.N.M. No. 127638c, U.S.N.M. 701c, Wolfcamp formation.

8. *Haplistion* species. Magnified view of part of the trabecular net of specimen called by Girty (1915, p. 18) "*Virgula* sp." and illustrated in that paper on plate 1, figure 11; U.S.N.M. No. 127629, from U.S.G.S. 2006 green. Wewoka formation.

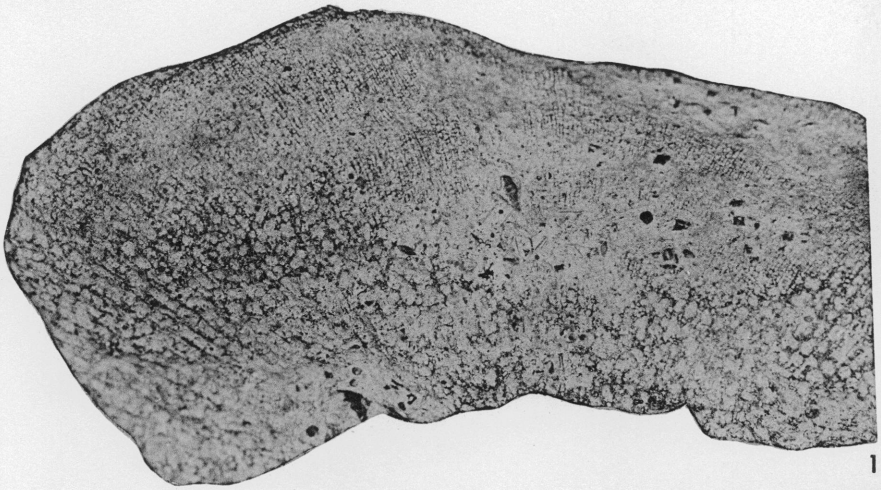
9, 10. *Chaunactis foliata* Finks, new species. 9. Magnified view of fine dermal mesh on flat side, holotype, U.S.N.M. No. 127640, from U.S.N.M. 700, Gaptank formation. 10. Magnified view of dermal mesh on edge of holotype.

3–7 are twice natural size; 1 and 2 are five times natural size; and 8–10 are 10 times natural size.

PLATE 29

Chaunactis foliata Finks, new species. All are from U.S.N.M. 700, Gaptank formation. 1. Enlarged view of convex side of holotype showing fine dermal mesh in upper part and coarser internal mesh below, U.S.N.M. No. 127640. 2. Enlarged view of edge of paratype, U.S.N.M. No. 127641b. 3. Enlarged view of convex side of same, nearly complete specimen lacking fine dermal mesh. 4. Enlarged view of opposite, concave, side of same specimen. 5. Magnified view of thin section parallel to top, or growing, edge of sponge, the two flat sides being above and below, respectively, paratype, U.S.N.M. No. 127641a. 6. Magnified view of thin section of same specimen, perpendicular to growing edge, which is at left; the flat sides of the sponge are above and below; monaxons parallel to the radial fibers can be seen in lower part of figure. 7. Magnified view of thin section of same specimen parallel to flat side of sponge showing long monaxons in radial fibers.

1–4 are twice natural size; and 5–7 are five times natural size.



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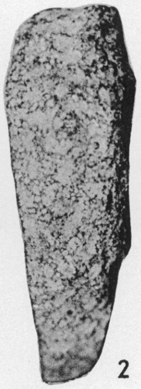

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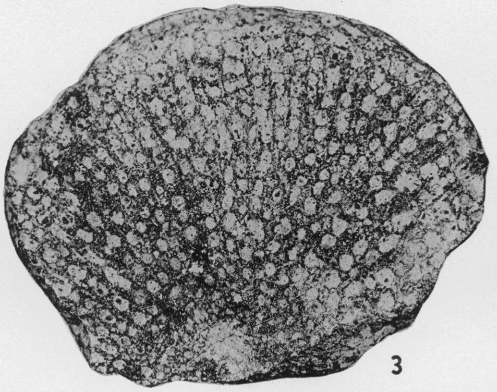

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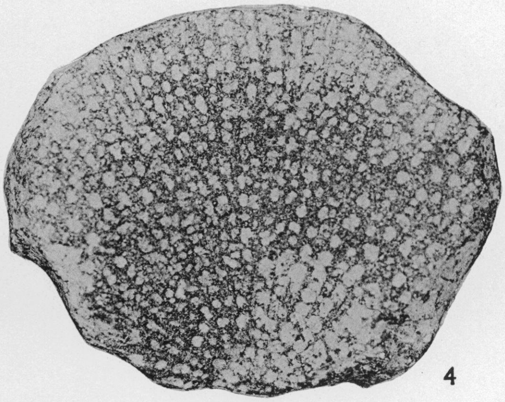

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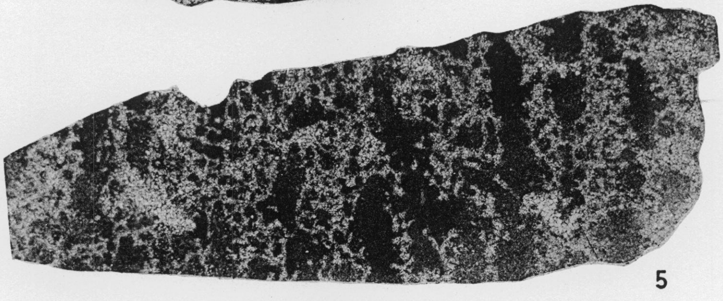

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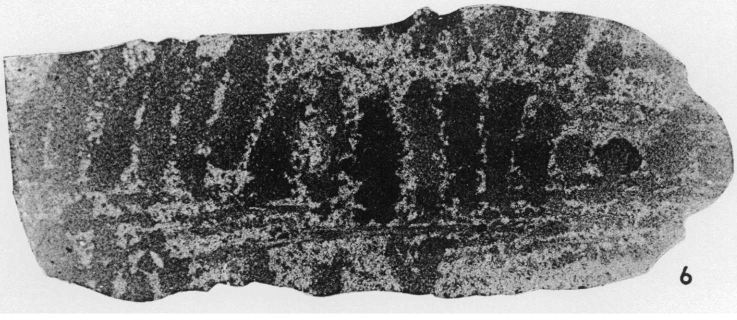

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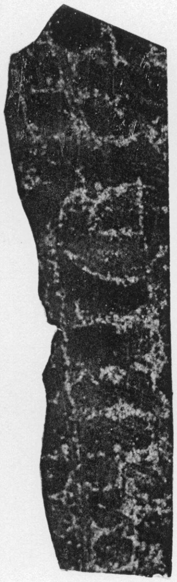

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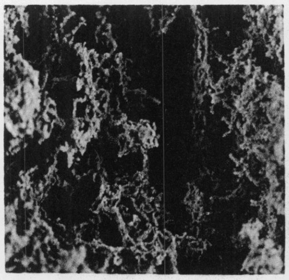

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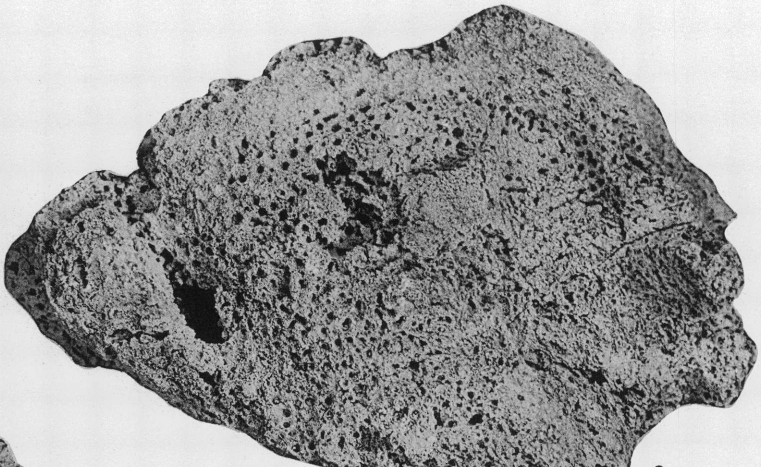

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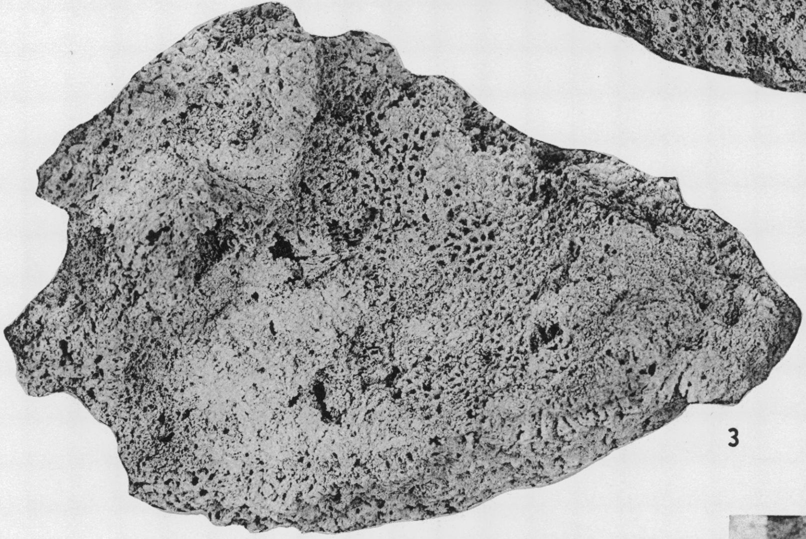

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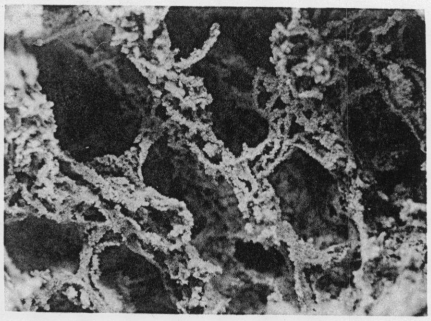

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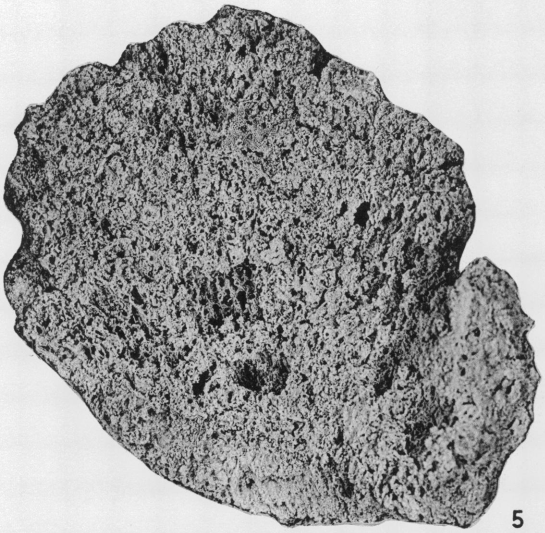

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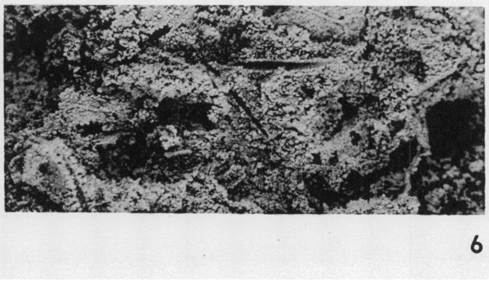

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PLATE 30

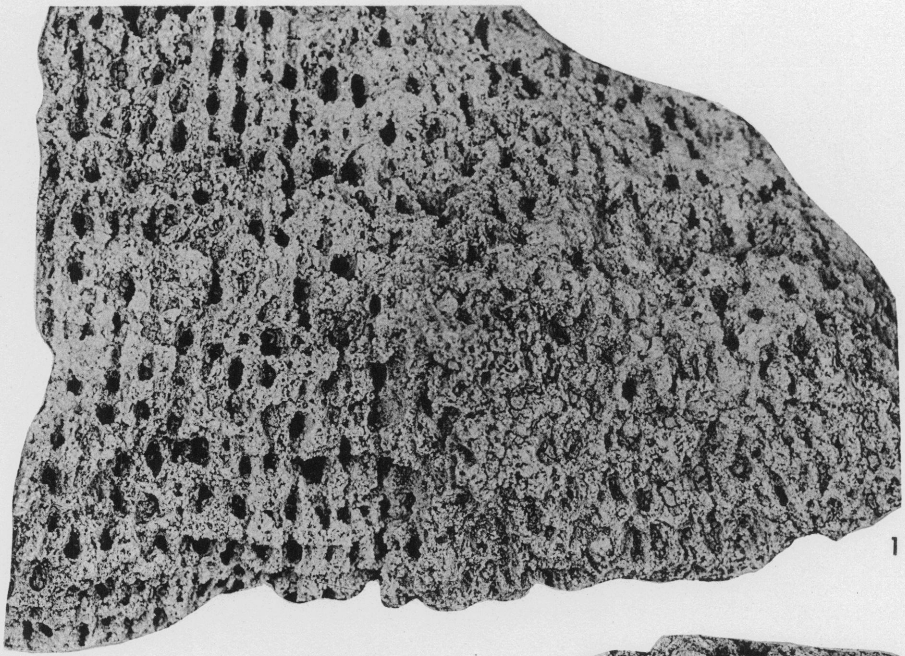
Chaunactis, species 1. All are from Y.P.M. 25, Permian of Las Delicias, Mexico 1. Magnified view of inner trabeculae, Y.P.M. No. 19607b. 2. Convex side of foliate specimen, Y.P.M. No. 19607a. 3. Concave side of same specimen. 4. Magnified view of inner trabeculae showing preservation as hollow tubes of anastomosing strands, Y.P.M. No. 19607b. 5. Concave side of same specimen. 6. Magnified view of molds of oxeas, possibly foreign, on outside of another specimen, Y.P.M. No. 19607c.

2, 3, and 5 are natural size; 4 is five times natural size; and 1 and 6 are 10 times natural size.

PLATE 31

Chaunactis, species 2. All are from Y.P.M. 192, Word formation. 1. Flat side of fragmentary specimen, growing edge at bottom, Y.P.M. No. 19605a. 2. Cross section of another specimen showing canals bowed towards growing edge at right, Y.P.M. No. 19605b. 3. Opposite side of specimen illustrated in 1, showing nearly imperforate layer pierced by large, circular pores, each on a slight eminence.

All are twice natural size.



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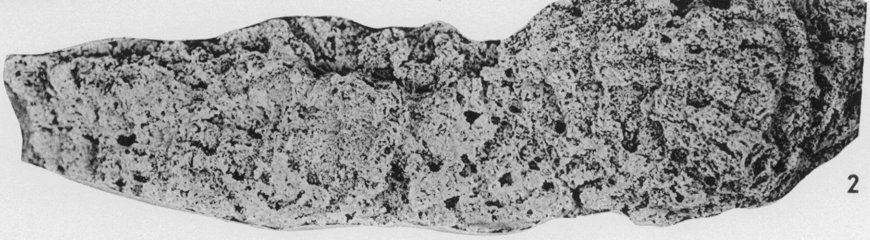

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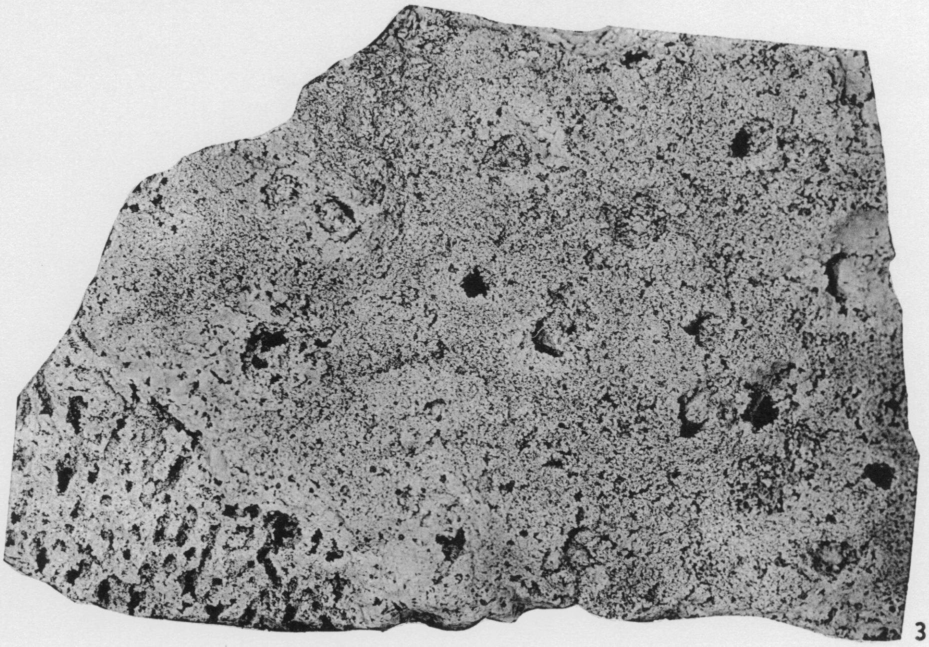

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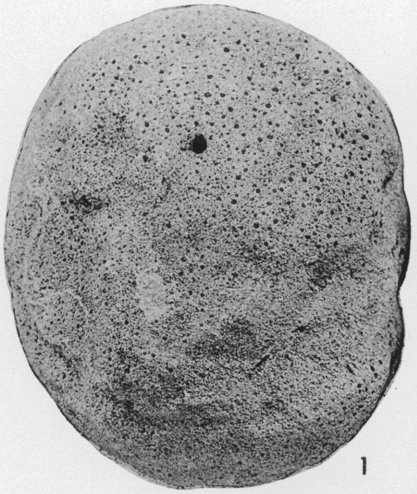

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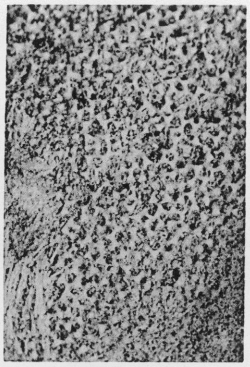

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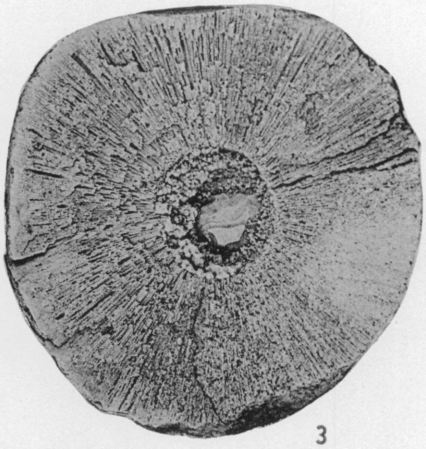

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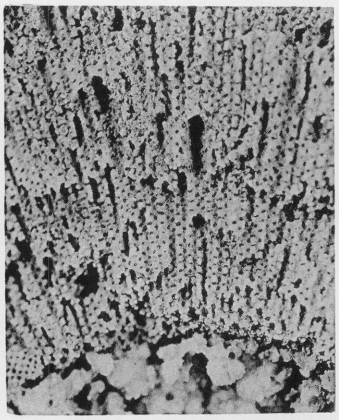

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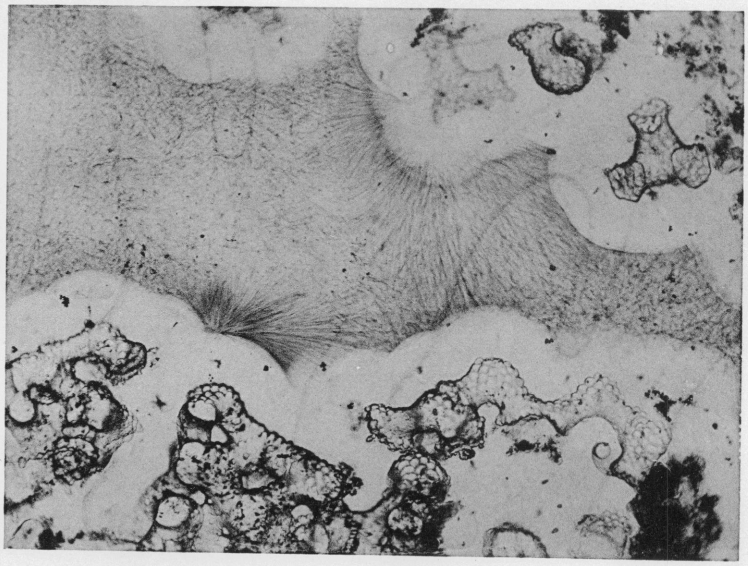

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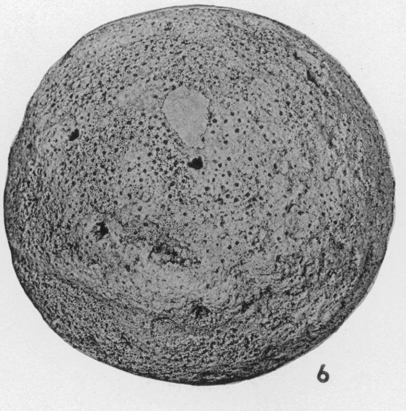

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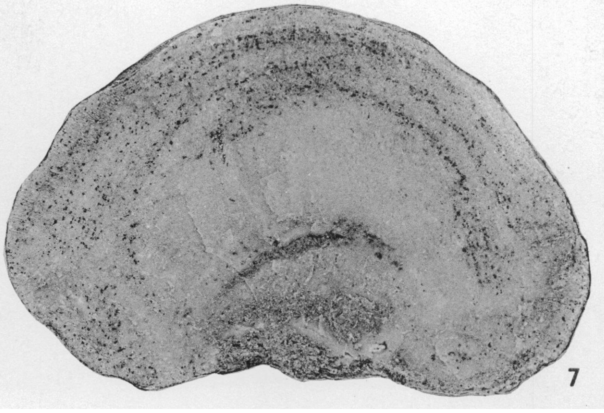

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PLATE 32

Scheiia tuberosa Tschernyschew and Stepanov. 1. Specimen showing skeletal pores, larger pores, and one oscule, A.M.N.H. No. 28072/1, from A.M.N.H. 500, Leonard formation. 2. Magnified view of surface of a specimen showing individual spicules outlining skeletal pores; the monaxons at lower left are probably foreign; A.M.N.H. No. 28072, from A.M.N.H. 666, Leonard formation. 3. Median section showing radiating rows of spicules and central hollow, A.M.N.H. No. 28072:1, from A.M.N.H. 666, Leonard formation. 4. Magnified view of same specimen showing radial canals and pores between individual spicules. 5. Thin section in median plane, top of photograph towards sponge surface; the net was apparently disrupted and much of it lost prior to deposition of fibrous chert which occupies center of figured area; at lower right spicules may be seen in natural position, with rays of adjacent spicules molded to the distal surface of the spicule beneath; at upper right an isolated spicule is seen as from below, showing the expanded ends of the three clads; the spherical tubercles covering the distal surface and the edges of the ray ends are clearly visible; the faint looping lines are the outlines of air bubbles in the mounting medium; U.S.N.M. No. 127643c, from U.S.N.M. 702, Leonard formation. 6. Specimen showing two sizes of pores and several oscules, U.S.N.M. No. 127643b, from U.S.N.M. 702, Leonard formation. 7. Sagittal section of a hemispherical specimen with a concave base, U.S.N.M. No. 127643a, from U.S.N.M. 702, Leonard formation.

1, 3, 6, and 7 are natural size; 2 and 4 are five times natural size; and 5 is 50 times natural size.

PLATE 33

1. *Scheiia tuberosa* Tschernyschew and Stepanov. Top of hemispherical specimen seen in sagittal section on plate 32, figure 7, U.S.N.M. No. 127643a, from U.S.N.M. 702, Leonard formation.

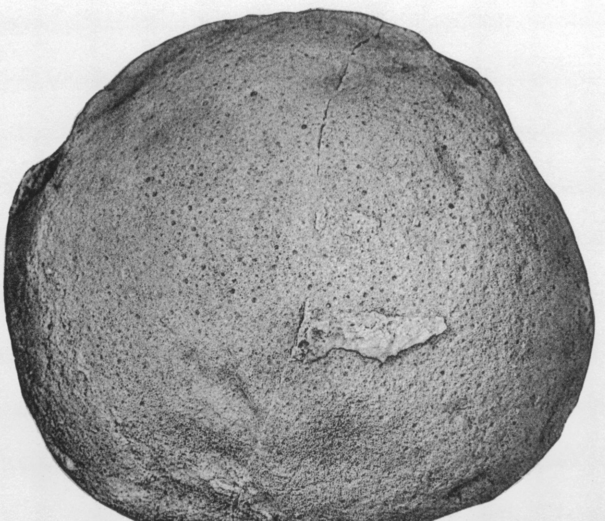
2–6. Isolated spicules. 2. Protraiaene, slide U.S.N.M. No. 127646, from U.S.N.M. 703c, Word formation. 3. Calthrops, the two on the right are spinose, slide U.S.N.M. No. 127646, from U.S.N.M. 703c, Word formation. 4. Spinose hexact, P.U. No. 78902, from P.U. 80c, Bone Spring limestone. 5. Cleme, probably from root tuft of *Dococlerma rigida* Finks, new species (compare pl. 40, fig. 10), slide U.S.N.M. No. 127646, U.S.N.M. 703c, Word formation. 6. Minutely spinose oxyhexaster, a hexact in which each ray is beset with spines and bears four terminal branches (the spines are barely visible), U.S.N.M. No. 127645, from U.S.N.M. 707ha, Leonard or Wolfcamp formation.

7. *Scheiia tuberosa* Tschernyschew and Stepanov. Basal surface of specimen shown in 1, U.S.N.M. No. 127643a, from U.S.N.M. 702, Leonard formation.

8. Surface of bed of spiculite, characteristic of basin facies, etched in acid; most of the spicules are monaxons; a large, rounded quartz pebble is at bottom and is the only terrigenous detritus evident on the slab of rock, U.S.N.M. No. 127644, from U.S.N.M. 707ha, Leonard or Wolfcamp formation.

9, 10. Isolated spicules. 9. Monaxons, three styles at left and three oxeas at right, slide U.S.N.M. No. 127647, from U.S.N.M. 703c, Word formation. 10. Two anadiaenes at left, probably from "Lyssacine, species 1," illustrated on plate 36, figures 1–7; the two unusual spicules at right (furculas) are derived from an unknown, probably lyssacine sponge, slide U.S.N.M. No. 127647, from U.S.N.M. 703c, Word formation.

1, 7, and 8 are natural size; 2, 3, 5, 9, and 10 are five times natural size; and 4 and 6 are 15 times natural size.



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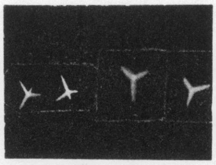

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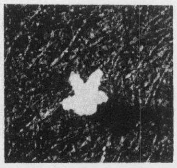

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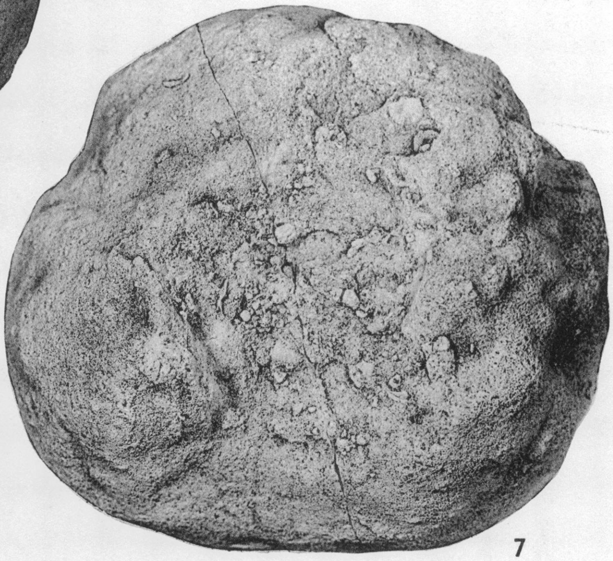

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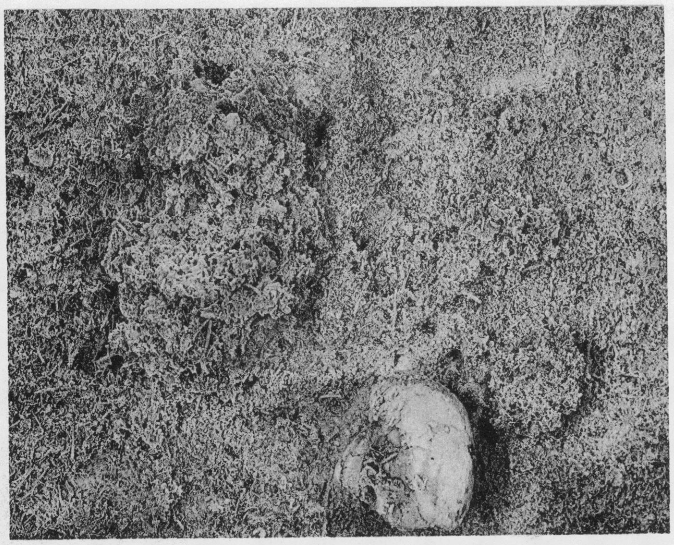

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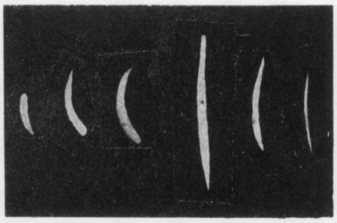

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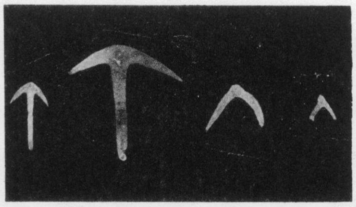

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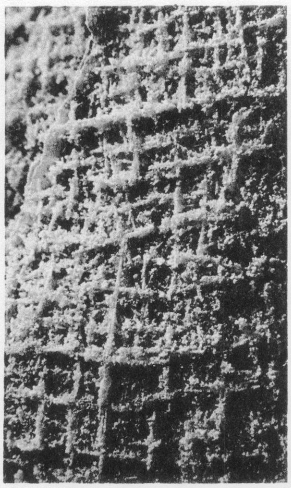
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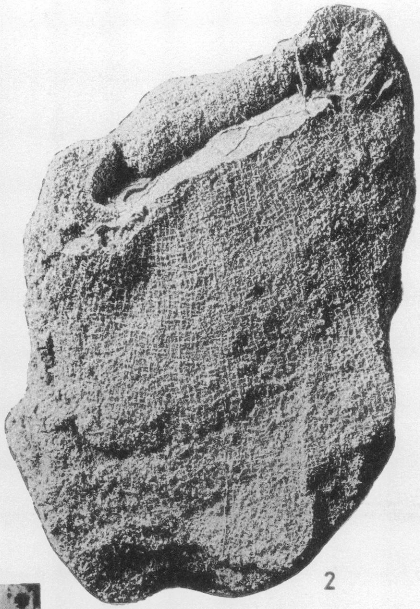
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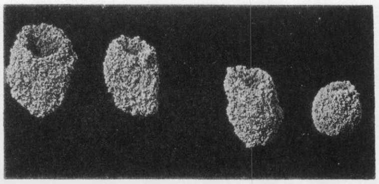
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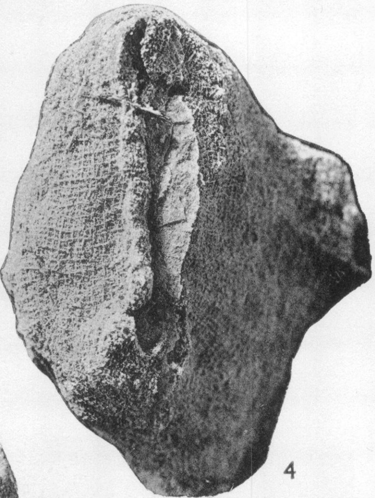
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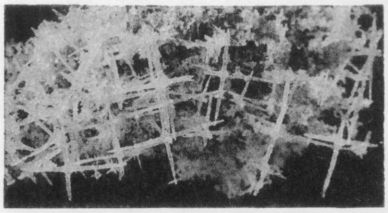
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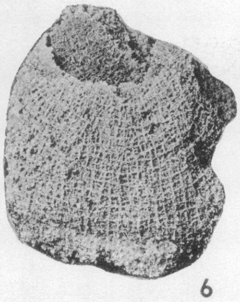
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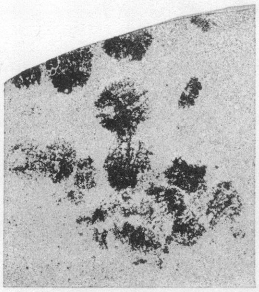
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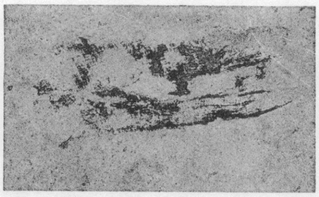
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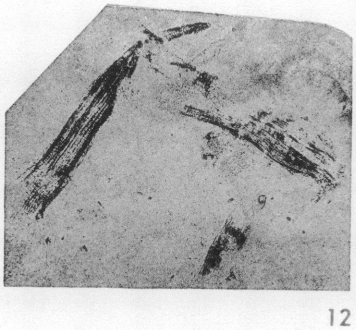
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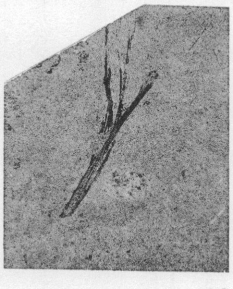
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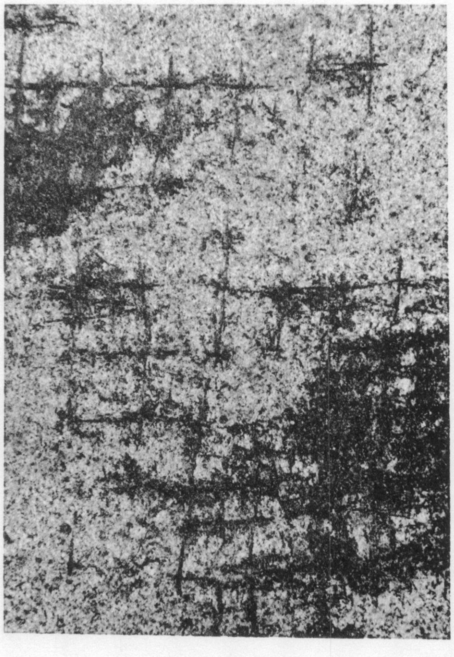
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PLATE 34

Microstaura doliolum Finks, new species. 1. Magnified view of surface of holotype, showing dermal pentacts, mostly of one size, with rays overlapping side to side, U.S.N.M. No. 127648, from U.S.N.M. 703c, Word formation. 2. Enlarged side view of holotype showing crushed oscular opening at top. 3. Enlarged view of four juveniles, U.S.N.M. Nos. 127649e, 127649f, 127649g, and 127649h, from U.S.N.M. 703c, Word formation. 4. Enlarged top view of holotype showing the somewhat prismatic outline. 5. Magnified view of outer surface of fragment showing inner cubic mesh formed by overlapping of simple hexacts, paratype, U.S.N.M. No. 127649d, from U.S.N.M. 703c, Word formation. 6. Enlarged side view of flattened specimen broken at each end; the cloacal wall is visible at the upper end of the figure; paratype, U.S.N.M. No. 127649b, from U.S.N.M. 703c, Word formation. 7. Enlarged view of cross section of same specimen, the upper end of preceding figure, showing cloaca. 8. Enlarged view of side of juvenile showing spicules; the oscular end is at bottom; paratype, U.S.N.M. No. 127649c, from U.S.N.M. 703c, Word formation. 9. Oscular end of same specimen. 10. Surface of slab of spicule-bearing, dark, basin-facies rock, covered with juveniles of this species, paratypes, A.M.N.H. No. 28073, from A.M.N.H. 675, Bone Spring limestone. 11. Reduced view of mature cylindrical specimen on slab from same locality, paratype, A.M.N.H. No. 28073:1. 12. Reduced view of another part of same slab showing three paratype specimens; the curved, pointed end of specimen at upper left may be a fourth individual, A.M.N.H. No. 28073:1. 13. Reduced view of root tuft, which may or may not belong to this species, on another slab from same locality, A.M.N.H. No. 28073:2. 14. Magnified view of specimen illustrated in 11, showing spicules of two orders of size; at upper left the rays are joined tip to tip rather than overlapping; paratype, A.M.N.H. No. 28073:1.

10 is natural size; 11–13 are one-half natural size; 2–4 and 6–9 are twice natural size; and 1, 5, and 14 are 10 times natural size.

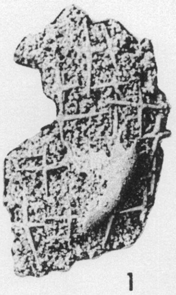
PLATE 35

1. *Endoplegma calathus* Finks, new species. Exterior of fragment probably belonging to this species, showing dermal pentacts in place; a shell fragment is adherent at lower right, paratype, U.S.N.M. No. 127650, from U.S.N.M. 703c, Word formation.

2–5. "Lyssacine species 2?" 2. Side of complete, but poorly preserved, specimen; numerous parietal gaps are visible, now somewhat elongate because of post-mortem compression, U.S.N.M. No. 127652a, from U.S.N.M. 703c, Word formation. 3. Oscular end of same specimen showing prismatic outline of the sponge. 4. Opposite end of same specimen. 5. Flat, compressed side of same specimen showing a few parietal gaps; the oscular end is here oriented downward, the pointed basal end at top.

6–11. *Endoplegma calathus* Finks, new species. 6. Reduced view of flattened side of holotype showing molds of dermal pentacts in silicified outer layer; strap-like bundles of monaxons are visible near basal end where the outer layer has been removed; they may once have projected as root tufts; U.S.N.M. No. 127651, from U.S.N.M. 703c, Word formation. 7. Reduced view of top of same specimen showing osculum and post-mortem compression; the row of nodes at the widest part of the sponge may be seen in profile at the left; the thin layer of monaxons lining the cloaca may be seen partially separated from the wall in lower part of figure. 8. Reduced view of oppsite side of sponge to that shown in 6. 9. Enlarged oblique view of part of osculum showing cloacal lining of strap-like bundles of monaxons in foreground; at left are approximately horizontal monaxons; at right they are covered by a vertical bundle. 10. View of area at upper left edge of 8, with oscular end to right, showing parietal gaps somewhat elongate owing to compression. 11. Enlarged view of part of surface shown in 8, showing dermal pentacts, here represented by molds, extending across the circular parietal gaps (upper right quadrant) which are outlined by the interior layer of monaxons.

1–5 and 10 are natural size; 6–8 are one-half natural size; and 9 and 11 are twice natural size.



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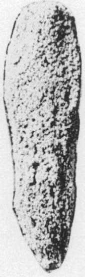

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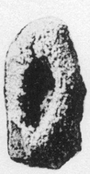

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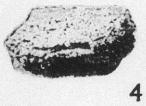

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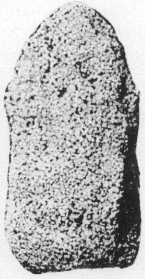

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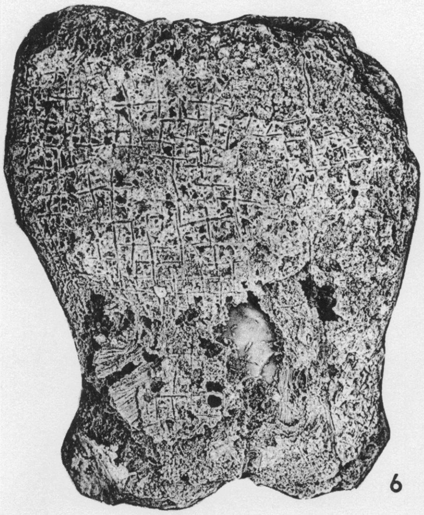

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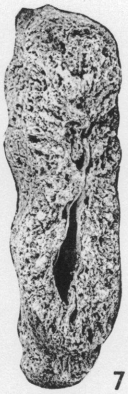

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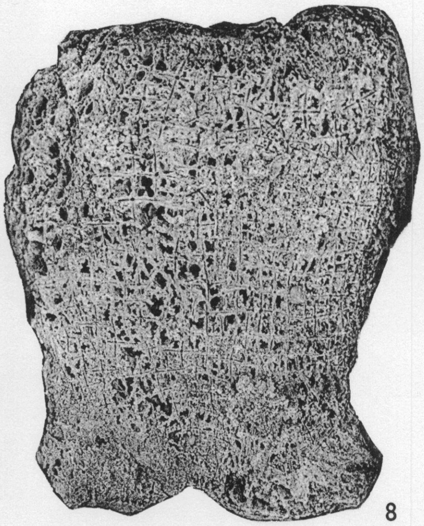

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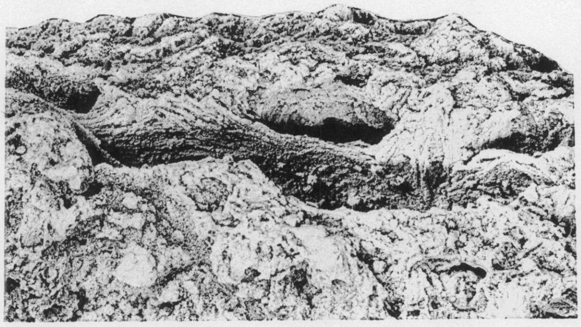

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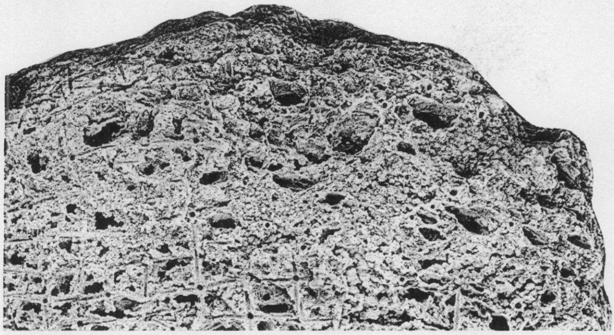

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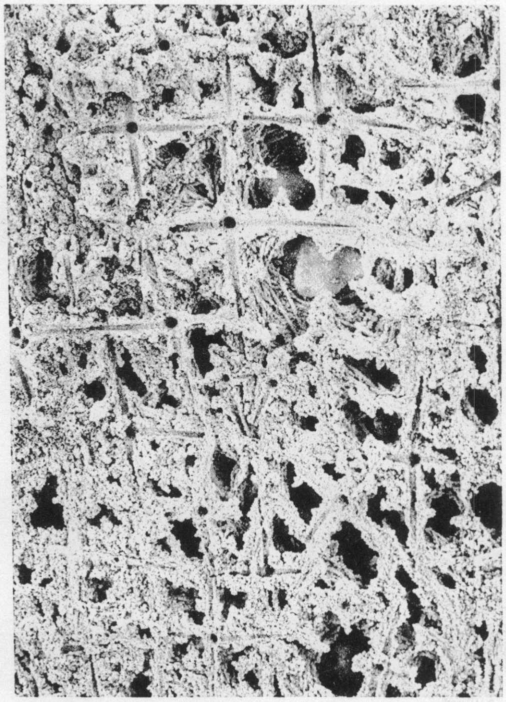

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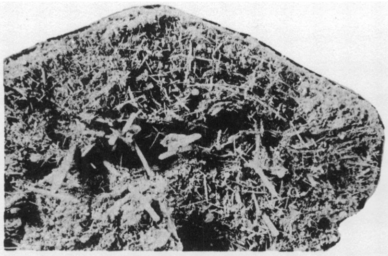
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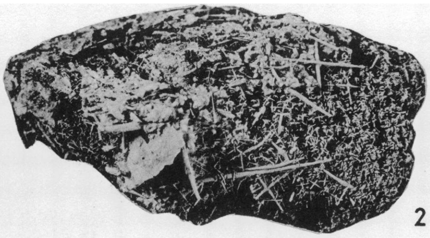
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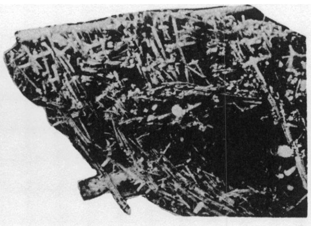
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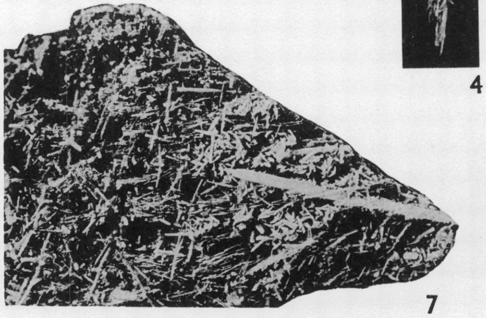
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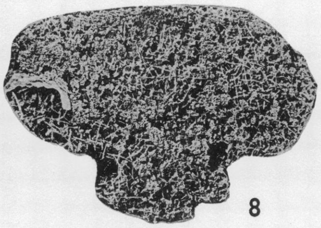
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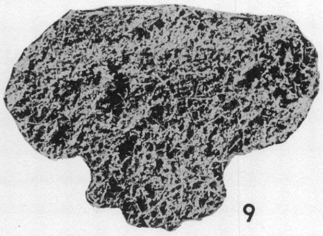
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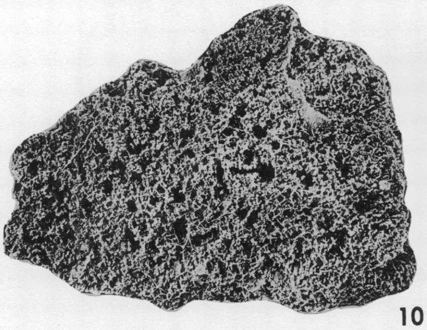
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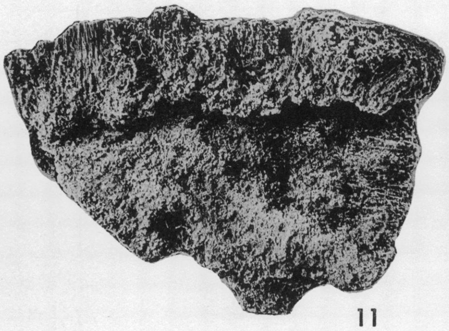
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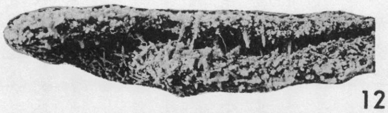
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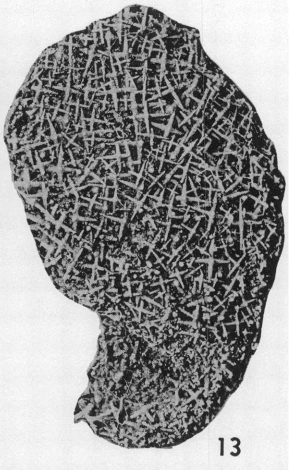
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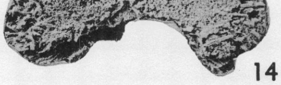
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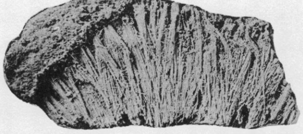
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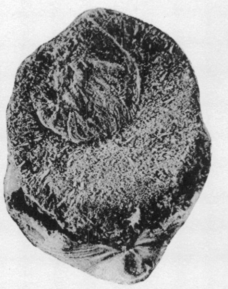
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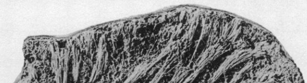
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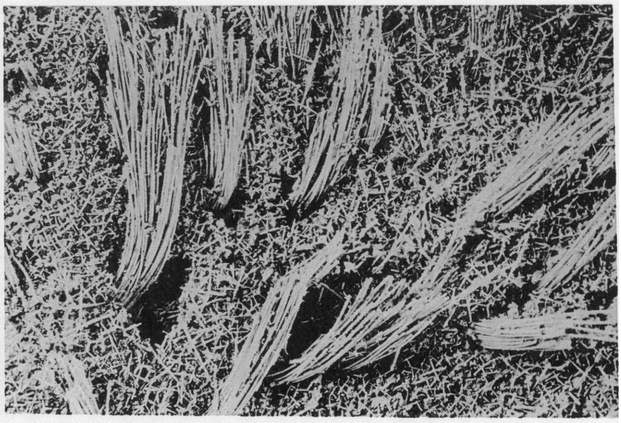
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PLATE 36

1–7. "Lyssacine, species 1." 1. Side of largest fragment, showing sagittal section, outer surface at top; the arrangement of the hexacts into concentric layers, parallel to the top surface, is visible; A.M.N.H. No. 28074, from A.M.N.H. 503, Word formation. 2. Outer surface of same specimen showing closely packed cladomes of anadiaenes, most easily seen at right; the largest spicules on the surface are probably foreign, such as the triact at lower center which probably came from a *Carphites* or related form; the large cross-shaped object at upper right is actually two oxeas, probably foreign. 3. Enlarged view of part of sagittal section of same specimen showing closely packed monaxons of various sizes perpendicular to surface; the surficial anadiaenes are just visible in side view at top, where there is also a large oxea, probably foreign, tangential to the surface. 4. Enlarged side view of an isolated group of anadiaenes from same specimen showing the approximately parallel orientation of the cladomes as seen edgewise. 5. View of similar group showing the anchor-shaped cladomes seen from the broad side. 6. Similar view of another group showing variation in size of anadiaenes. 7. Enlarged view of surface of same specimen showing circular pores and ends of oxeas and anadiaenes; the large oxea at right, which is also visible in 3, is probably foreign.

8–11. "Lyssacine, species 2." 8. Outer surface of fragment showing circular prosopore, and arrangement of hexacts; the object at left is a shell fragment adherent to the surface A.M.N.H. No. 28075, from U.S.N.M. 703c, Word formation. 9. Inner, presumably cloacal, surface of same specimen. 10. Outer surface of a larger fragment showing prosopores; the edge at right may have been the oscular rim (the irregular white line at upper right is the edge of the silica filling of a fracture in the rock which passes through the specimen), A.M.N.H. No. 28075:1, from U.S.N.M. 703c, Word formation. 11. Opposite side of same specimen, probable oscular rim at right; the specimen is bent so that the upper part of the figure presents a complete section through the body wall, outer surface at top, and shows the numerous thin monaxons perpendicular to the outer surface; the lower part of the figure shows the cloacal surface, its structure somewhat obscured by a siliceous vein filling; at right parallel monaxons are visible tangential to the cloacal surface and perpendicular to the oscular rim.

12, 13. "Lyssacine, species 3." 12. Enlarged view of broken edge of highly compressed specimen showing a section through the whole sponge, which consists essentially of a single layer of pentacts; the proximal rays of those on top surface can be seen projecting into the hollow interior, U.S.N.M. No. 127653, from U.S.N.M. 703c, Word formation. 13. Enlarged view of outer surface of same specimen showing arrangement of pentacts; each has a small node in place of aborted distal ray.

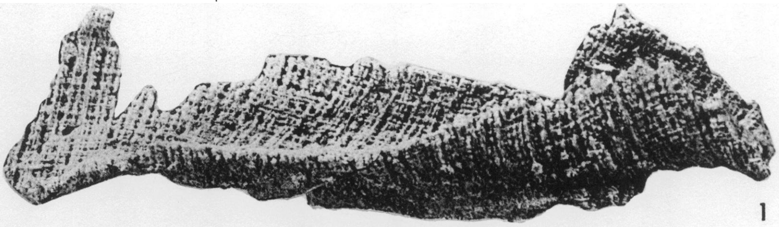
14–18. *Polylophidium discus* Finks, new species. 14. Exterior of an incomplete discoidal specimen showing the characteristic tufts of monaxons, paratype, A.M.N.H. No. 28076:2, from A.M.N.H. 503, Word formation. 15. Another fragmentary specimen with part of the outer layer removed to reveal the radial bundles of monaxons in the interior, which end as the external tufts, paratype, A.M.N.H. No. 28076:1, from A.M.N.H. 503, Word formation. 16. A complete discoidal specimen, the holotype, lodged in a brachiopod shell; in addition to the regular small tufts evenly distributed over the surface, this specimen shows a continuous ring of monaxons at upper left which may have been a root tuft; A.M.N.H. No. 28076, from A.M.N.H. 503, Word formation. 17. Outer surface, and reverse side, of specimen illustrated in 15, showing well-developed tufts, paratype, A.M.N.H. No. 28076:1, from A.M.N.H. 503, Word formation. 18. Magnified view of surface illustrated in preceding figure, showing dermal layer of pentacts and stauracts of various sizes, pierced by tufts of monaxons; note the flat ends of the individual monaxons.

8–11 and 14–17 are natural size; 1, 2, 12, and 13 are twice natural size; 3, 7, and 18 are five times natural size; and 4–6 are 10 times natural size.

PLATE 37

Stereodictyum orthoplectum Finks, new species. 1. Fragment of thin-walled, conical individual, oscular end probably towards left, paratype, A.M.N.H. No. 28077, from A.M.N.H. 369, Bone Spring limestone. 2. Enlarged view of surface of another fragmentary, thin-walled individual, showing strap-like bundles of spicules; horizontal bundles constitute the outermost layer; note the rows of pores produced by the periodic omission of longitudinal and annular bundles; paratype, A.M.N.H. No. 28077:1, from A.M.N.H. 369, Bone Spring limestone. 3. Outer surface of holotype, a fragment of a thick-walled individual; this surface is eroded and is not the original exterior, U.S.N.M. No. 127654, from U.S.N.M. 701a2, Wolfcamp formation. 4. Cross section of same specimen, cloacal surface at right. 5. Sagittal section of same specimen, cloacal surface at left; the vaguely defined circular areas where the net is absent are probably an accident of preservation. 6. Cloacal surface of same specimen showing apopores; a dislocation of the net is visible along a vertical line about 2 cm. from the right edge.

All natural size, except 2 which is twice natural size.



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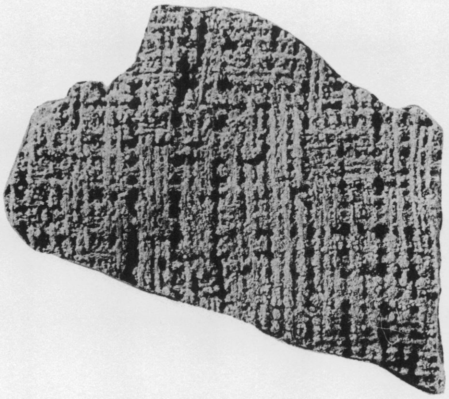

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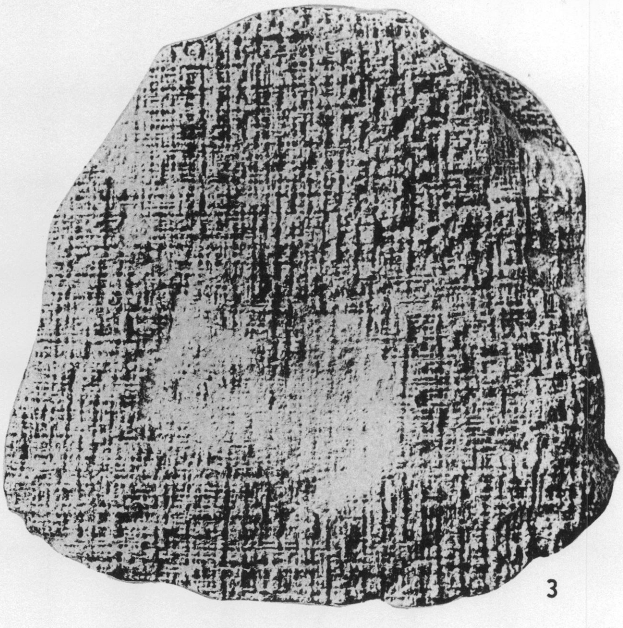

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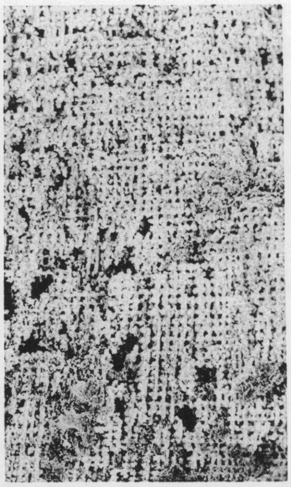

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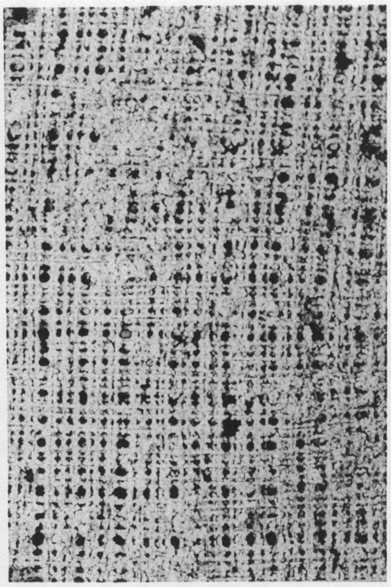

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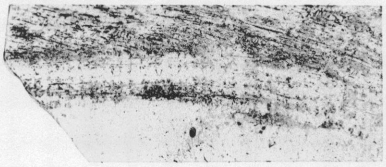

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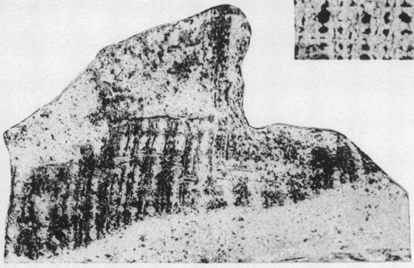

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PLATE 38

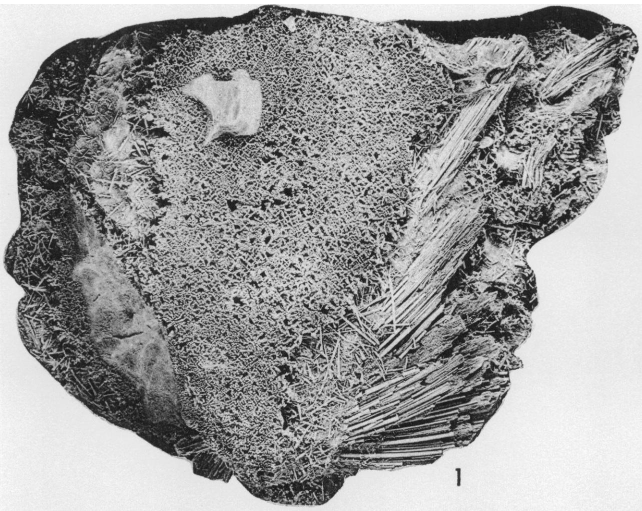
Stereodictyum orthoplectum Finks, new species. 1. Enlarged view of cloacal surface of large specimen, oscular end probably towards top, paratype, U.S.N.M. No. 127655, from U.S.N.M. 701, Wolfcamp formation. 2. Enlarged view of cross section of same specimen, cloaca to left. 3. Enlarged view of exterior surface of same specimen showing the regular distribution of larger prosopores. 4. Enlarged view of part of calcified, thin-walled specimen embedded in matrix, showing oblique section of wall in center and, above, a surface parallel to the wall showing individual spicules, paratype, U.S.N.M. No. 127656, from U.S.G.S. 7004, Hueco limestone. 5. Enlarged view of other side of same specimen showing wall surface with individual spicules visible. 6. Magnified view of thin section of another calcified fragment; the section is probably in the radial vertical plane; at the bottom are cross sections of the annular spicule bundles, and in center some spicules, apparently reduced hexacts, participate in both the vertical and radial bundles; the cloaca may have been at left and the oscular end towards the top; paratype, U.S.N.M. No. 127657a, from U.S.G.S. 7001a, Hueco limestone. 7. Magnified view of thin section of same specimen in tangential vertical plane; the vertical axis of the sponge is horizontal here, with the oscular end possibly at right; an annular spicule bundle crosses the figure from top to bottom and shows curving connections with the longitudinal bundles at left.

1–5 are twice natural size, and 6 and 7 are 50 times natural size.

PLATE 39

Docoderma rigida Finks, new species. 1. Basal end of holotype showing root tuft, U.S.N.M. No. 127659, from U.S.N.M. 703c, Word formation. 2. View of lower end of same figure; this may be a single individual complexly folded in upon itself, in the manner visible in the upper part of this figure. 3. Opposite side to that illustrated in 1, showing the broken-off basal end of the sponge at lower left. 4. Opposite side to that illustrated in 2, showing a cross section of the complexly folded sponge; a deep invagination of the outer layer extends horizontally across the block from left center, opposite the shallower invagination at the right end. 5. Side of a second block containing the upper half of the same specimen; this fits on to the upper end of 1. 6. Lower edge of the block illustrated in 5 showing a cross section of the sponge; this fits against the face shown in 4, the right end of the present figure corresponding to the left end of 4.

All are one-half natural size.



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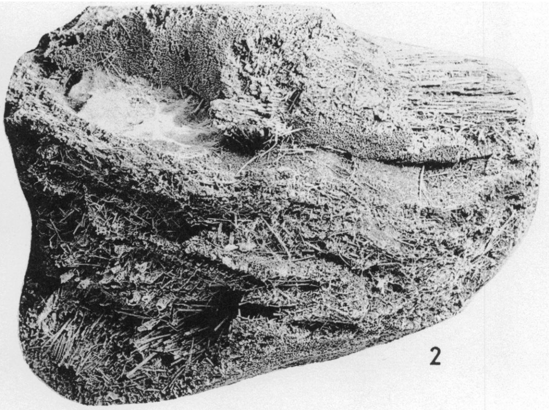

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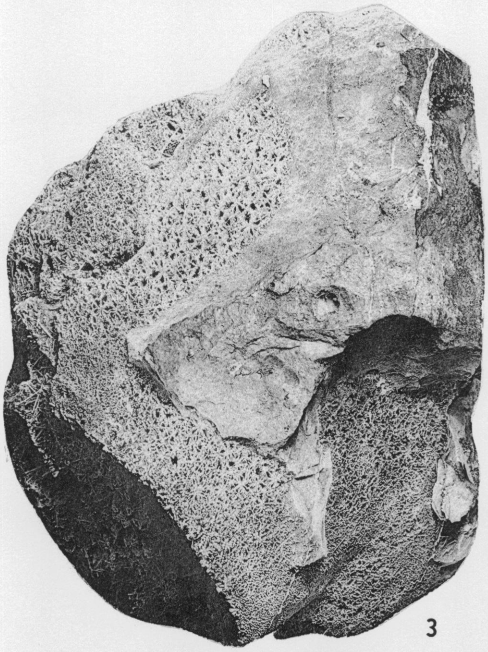

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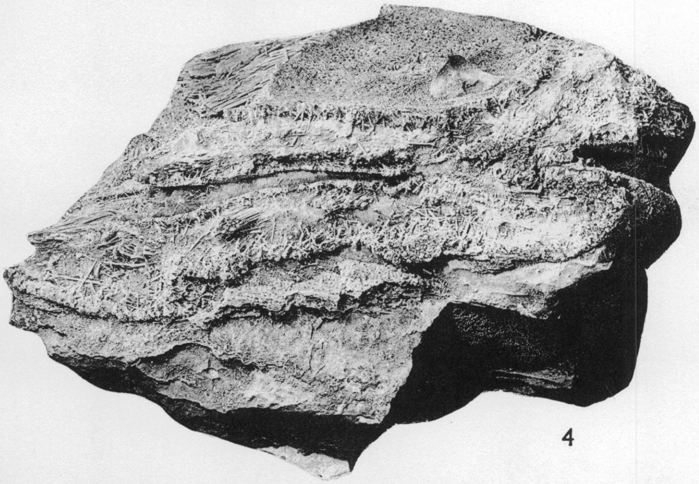

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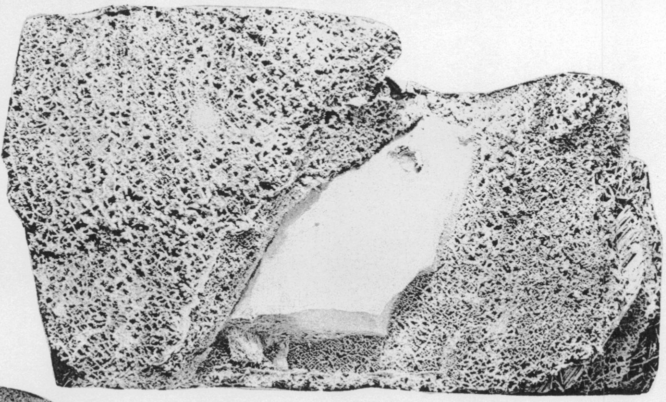

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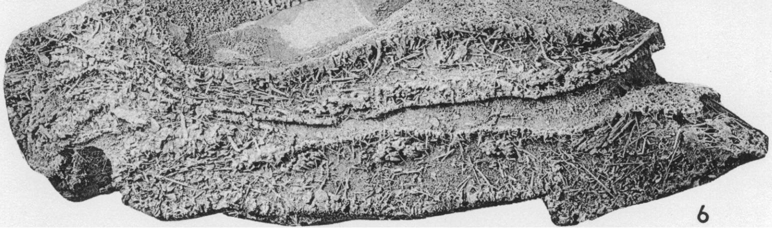

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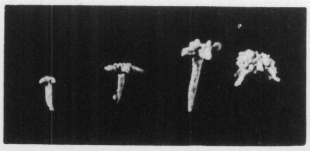
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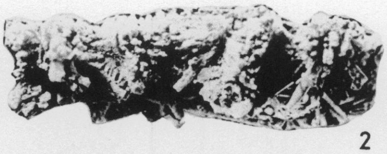
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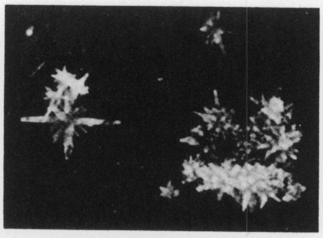
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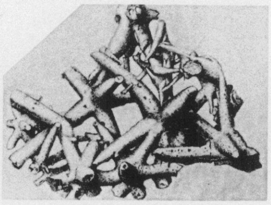
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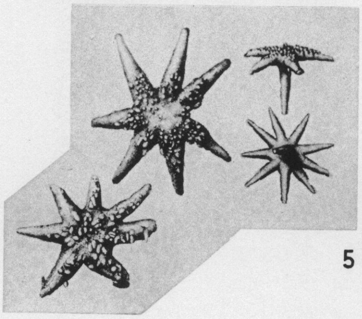
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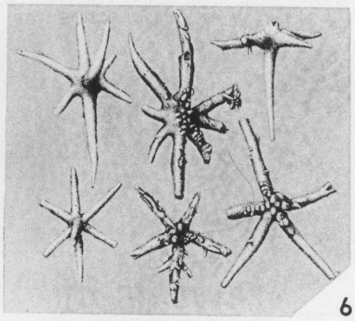
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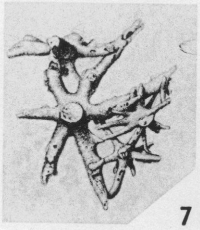
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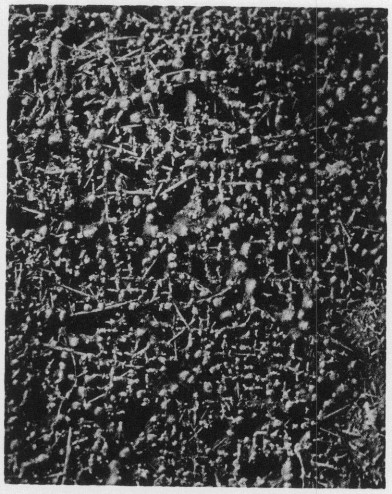
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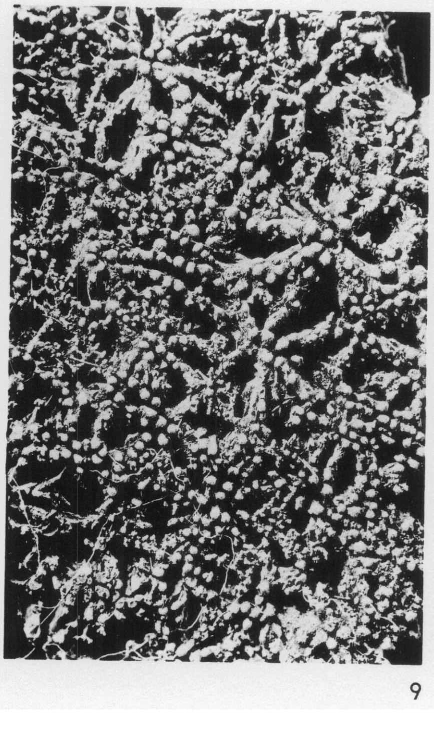
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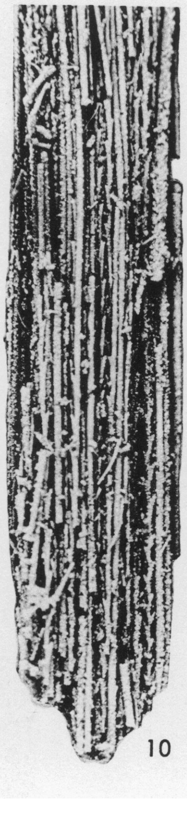
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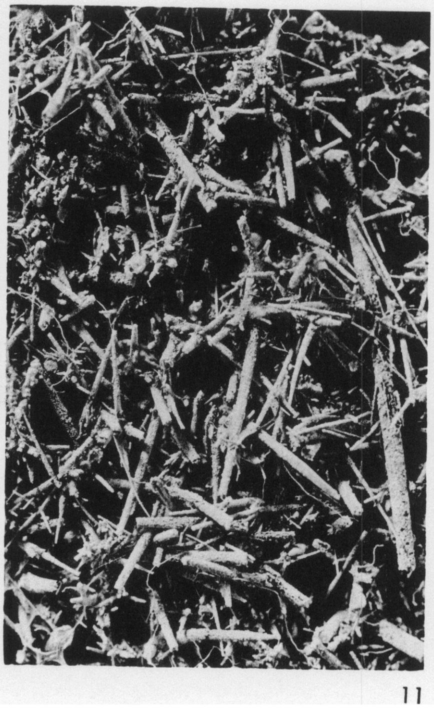
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PLATE 40

1. Isolated spicules of *Docoderma* cf. *rigida*. The three at the left are dermal pentacts with varying degrees of ornamentation; on the right is a characteristic dermal stauract with strongly reflexed tangential rays and several supernumerary rays on the upper surface, A.M.N.H. Nos. 28078:1–28078:4, from A.M.N.H. 369a, Bone Spring limestone.

2, 3. *Docoderma rigida* Finks, new species. 2. Magnified side view of dermal layer, removed from holotype; the spicule at left shows a broken proximal ray (8 mm. to right of lower left corner) with two strongly reflexed tangential rays on each side and another above and in front of it, directed obliquely down towards the observer; each tangential ray is surmounted by supernumerary rays which interdigitate with those of adjacent spicules, as is visible about 12 mm. from the right edge; U.S.N.M. No. 127659a, from U.S.N.M. 703c, Word formation. 3. Magnified view of dermal spicules isolated from juvenile specimens; the large spicule at left is a pentact viewed from the inner side; the tangential rays, forming a cross, are each directed at about a 45-degree angle towards the observer; the rosette of supernumerary tangential rays is visible about the crossing; two smaller spicules adherent to one of the tangential rays can be seen at top; at the right of the figure is a group of spicules seen from the dermal side and showing the rosettes of extra tangential rays; U.S.N.M. No. 127660d, from U.S.N.M. 703c, Word formation.

4, 5. *Tholiasterella youngi* (Hinde). 4. Magnified view of portion of dermal layer seen from interior showing interlocking and fusion of the spicules; this is a topotype specimen of the genotypic species, Law Quarry, Dalry, Ayrshire, Scotland, upper part of lower limestone series, lower Carboniferous; from Hinde (1888a, pl. 7, fig. 2). 5. Magnified view of isolated dermalia from type locality; compare with 9, this plate; note that the spicule at upper left is shown at twice the magnification of the others; from Hinde (1888a, pl. 7, figs. 2a–d).

6, 7. *Tholiasterella gracilis* Hinde. 6. Magnified view of isolated dermalia from same locality and horizon as preceding; from Hinde (1888a, pl. 7, figs. 1c–g). 7. Magnified view of dermal layer seen from inside, showing interlocking of branching rays, same locality and horizon as preceding; from Hinde (1888a, pl. 7, fig. 1a).

8–11. *Docoderma rigida* Finks, new species. 8. Magnified view of surface of holotype showing supradermal quadrate mesh; the regular dermalia, as shown in following figure, can be discerned beneath; U.S.N.M. No. 127659, from U.S.N.M. 703c, Word formation. 9. Magnified view of surface of fragment of holotype showing main dermal skeleton; each star-shaped configuration is formed by the outer rays of the branching beams of vertically fused supernumerary rays of a single spicule; note the spherical nodes on the beam edges and the non-circular parietal gaps. 10. Magnified view of part of root tuft of holotype showing several clemes amongst smooth monaxons, especially at lower right. 11. Magnified view of interior side of dermal layer illustrated in 9; in addition to the reflexed tangential rays of the surface spicules, which form most of the largest rays visible in the figure, there are several hexacts of the choanosome; note the circular outlines of the parietal gaps on the interior in contrast to their appearance in 9.

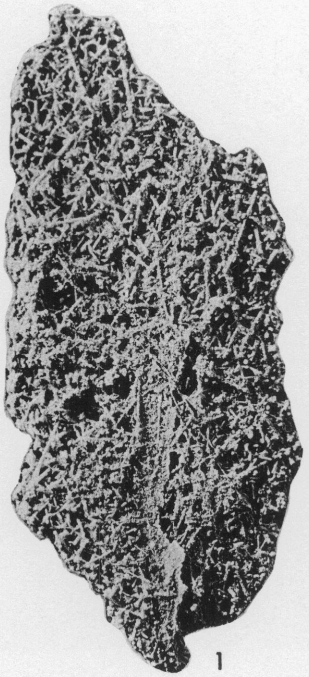
1 is natural size; 2–9 and 11 are five times natural size, except for the spicule at upper left in 5, which is 10 times natural size; and 10 is 10 times natural size.

PLATE 41

1, 2. *Docoderma rigida* Finks, new species. 1. Enlarged view of inside of dermal layer of juvenile individual; compare with plate 40, figure 11, which is to same scale; paratype, U.S.N.M. No. 127660b, from U.S.N.M. 703c, Word formation. 2. Enlarged view of exterior of juvenile, showing the small parietal gaps for comparison with plate 40, figure 9; paratype, U.S.N.M. No. 127660c, from U.S.N.M. 703c, Word formation.

3–6. *Docoderma papillosum* Finks, new species. 3. Enlarged view of exterior of fragmentary specimen showing parts of two large dermal stauracts with characteristic tubercles on surface of rays as well as the smaller star-shaped dermalia between them; paratype, P.U. No. 78901, from P.U. 1r, Bone Spring limestone. 4. Magnified view of portion of cloacal surface of another specimen showing rigid layer of tuberculate stauracts smaller and more slender than dermal spicules, paratype, P.U. 78900, from P.U. 1r, Bone Spring limestone. 5. Magnified view of opposite side of same fragment showing finer choanosome spicules. 6. Enlarged view of opposite side of specimen illustrated in 3, showing choansome spicules and obscure parietal gap, paratype, P.U. No. 78901, from P.U. 1r, Bone Spring limestone.

3 and 6 are twice natural size; the other figures are five times natural size.



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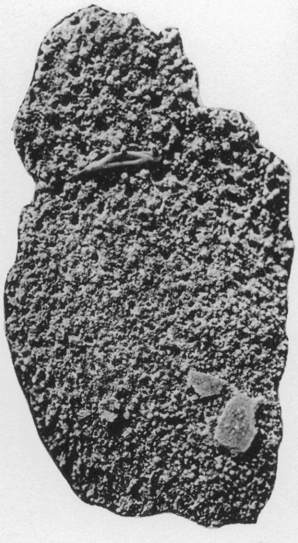

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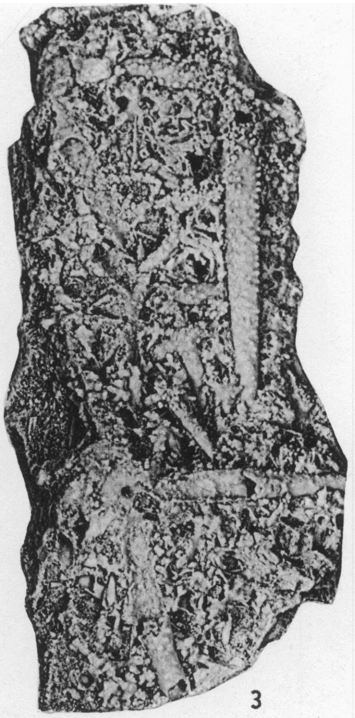

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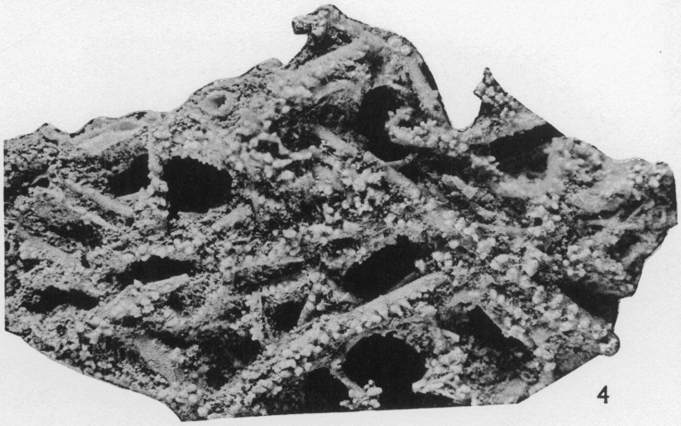

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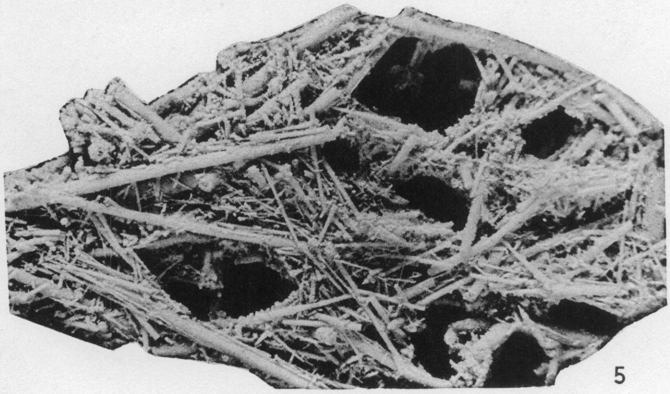

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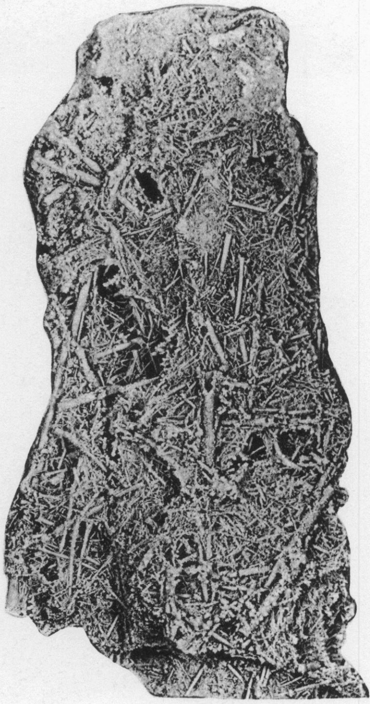

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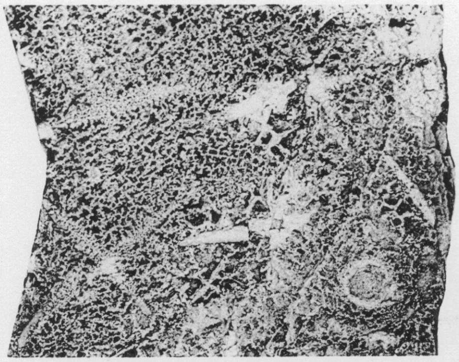
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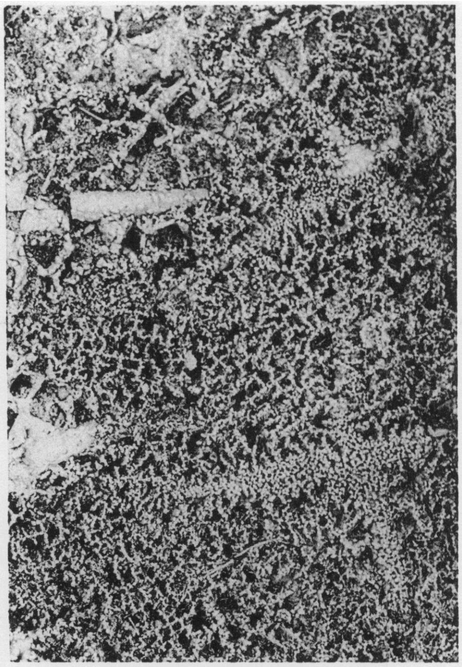
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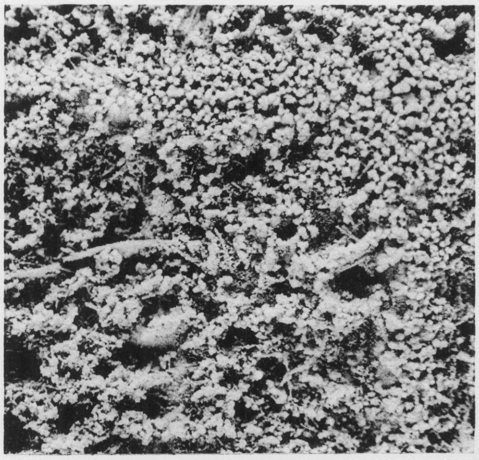
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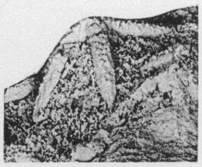
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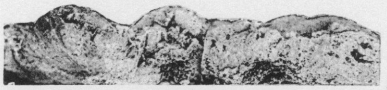
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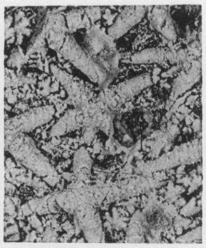
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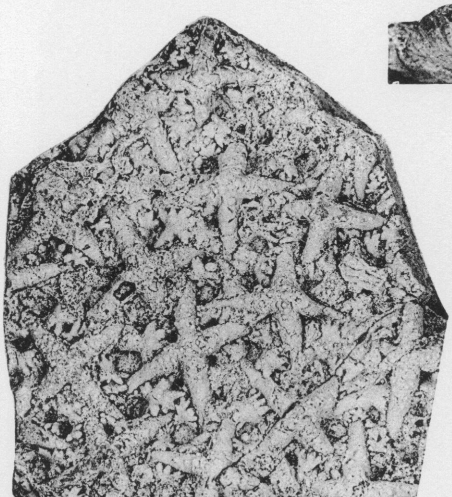
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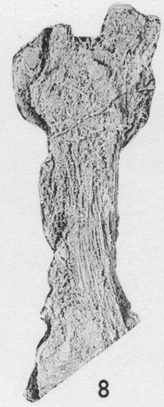
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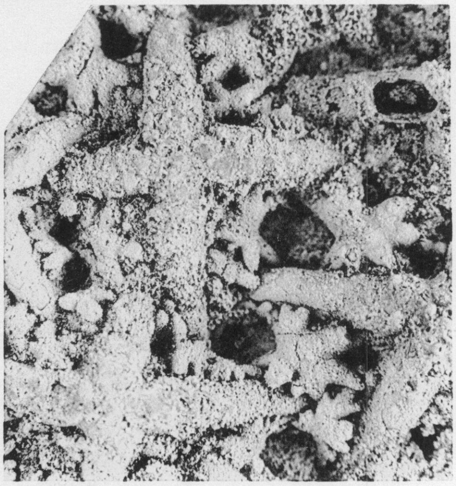
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PLATE 42

1–7. *Docoderma papillosum* Finks, new species. 1. Exterior of a fragmentary specimen showing large dermal stauracts or pentacts, supradermal quadrate mesh, and, at lower right, a circular opening at the summit of a conical elevation which may be a parietal gap; paratype, P.U. No. 78897, from P.U. 1rc, Bone Spring limestone. 2. Enlarged view of same specimen showing well-developed quadrate mesh, large tubercles on spicules (upper left), and profuse development of smaller tubercles (right). 3. Magnified view of part of spicule at lower right of preceding figure, showing small tubercles and their continuation into quadrate mesh. 4. Side view of dermal pentact or stauract showing reflection of tangential rays, paratype, P.U. No. 78896, from P.U. 1L. 5. Enlarged side view of dermalia of holotype showing reflexing of tangential rays, P.U. No. 78885, from P.U. 1rc, Bone Spring limestone. 6. Enlarged view of large dermalia showing extra tangential ray on spicule in center, paratype, P.U. No. 78884, from P.U. 1rc, Bone Spring limestone. 7. Enlarged view of exterior of holotype showing larger dermalia with coarse papillae and smaller star-shaped dermalia with numerous stubby, branching, tangential rays, P.U. No. 78885, from P.U. 1rc, Bone Spring limestone.

8. *Carphites diabloensis* Finks, new species. Reduced view of part of root tuft adherent to fragment of dermal layer (not visible) which may belong to this species, P.U. No. 78894, from P.U. 1r, Bone Spring Limestone.

9. *Docoderma papillosum* Finks, new species. Magnified view of part of surface illustrated in 7, showing stellate dermalia between and molded to the tangential rays of the larger pentacts, holotype, P.U. No. 78885, from P.U. 1rc, Bone Spring limestone.

1 and 4 are natural size; 8 is one-half natural size; 2, 5, 6, and 7 are twice natural size; and 3 and 9 are five times natural size.

PLATE 43

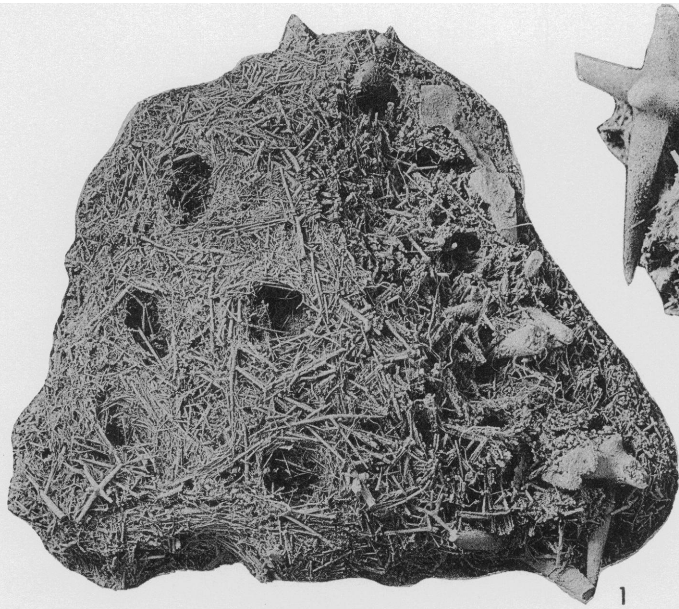
1, 2. *Carphites plectus* Finks, new species. 1. Enlarged view of gastral surface of fragmentary specimen showing internal openings of parietal gaps and triact spicules; at right is an obliquely broken surface revealing the large dermal spicules, paratype, U.S.N.M. No. 127662a, from U.S.N.M. 703c, Word formation. 2. Enlarged view of dermal surface of same specimen; bundles of triacts may be seen accompanying the large dermal spicules as comitalia and also forming an independent mesh; small bundles may be seen exterior to the large dermalia at the bottom, and larger bundles of the deeper layers may be seen at upper right.

3. *Carphites diabloensis?* Finks, new species. Enlarged view of a possibly juvenile specimen with finer triacts and a single large dermal pentact, A.M.N.H. No. 28079, from A.M.N.H. 503, Word formation.

4. *Carphites diabloensis* Finks, new species. Enlarged view of dermal surface of holotype showing dermal pentacts, P.U. No. 78891, from P.U. 1r, Bone Spring Limestone.

5, 6. *Carphites plectus* Finks, new species. 5. Enlarged view of broken edge of holotype showing exterior surface at top, with dermal hexacts, and gastral surface at bottom; note the large triacts of the choanosome oriented parallel to the surface; U.S.N.M. No. 127661, from U.S.N.M. 703c, Word formation. 6. Enlarged view of outer surface of same specimen showing dermal hexacts, fine dermal triacts (see lower right), and circular parietal gaps.

All are twice natural size.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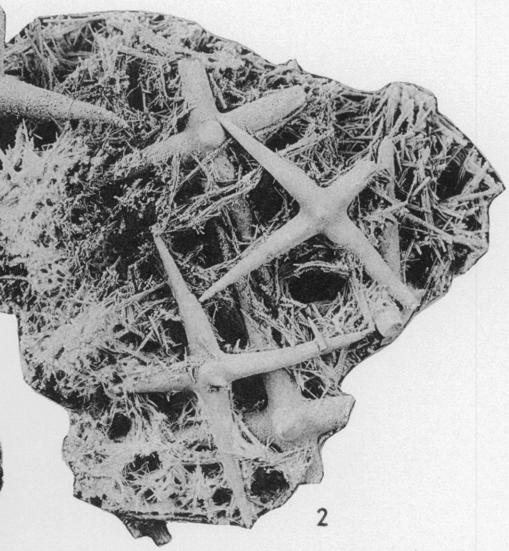
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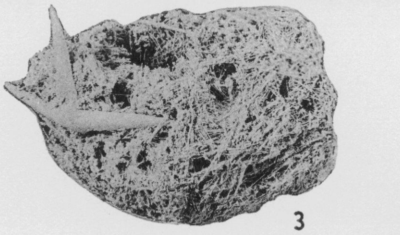
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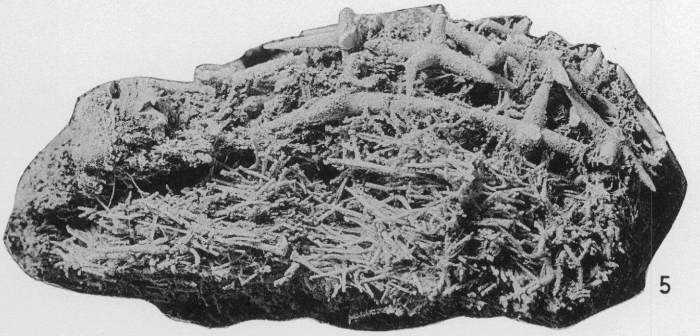
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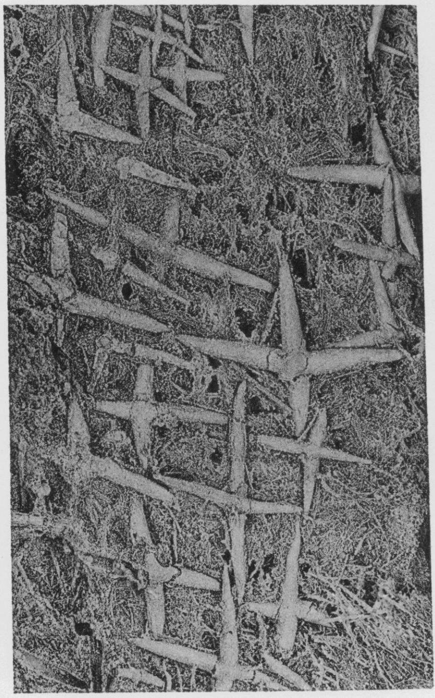
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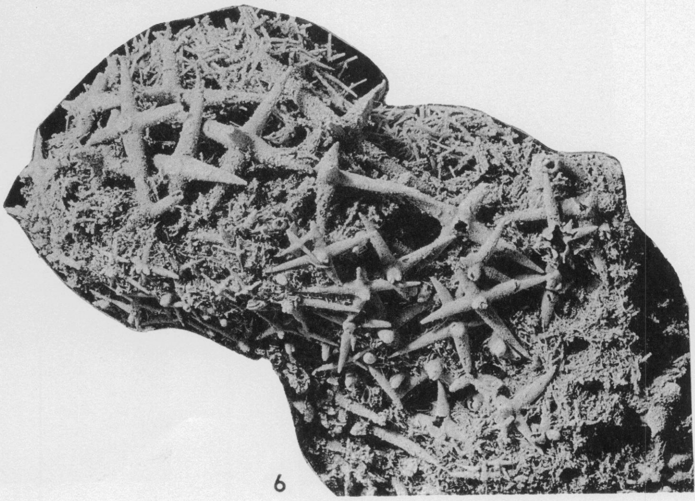
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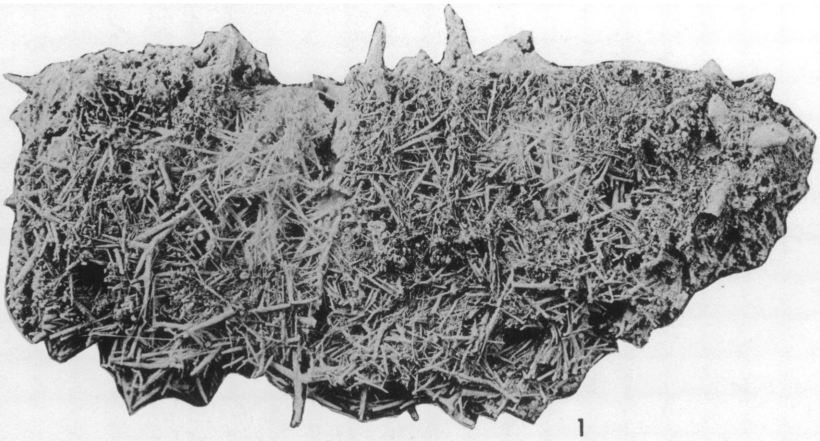

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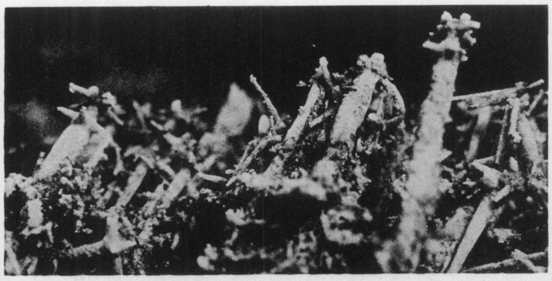

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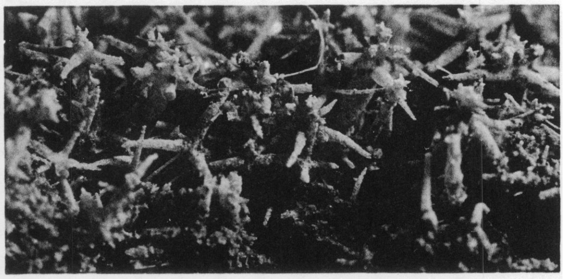

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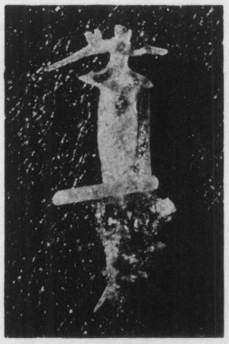

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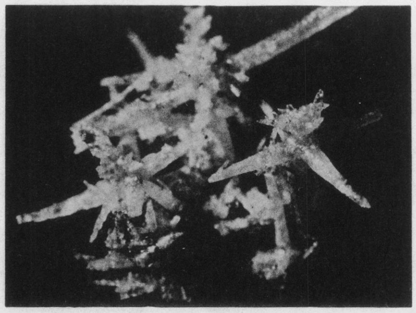

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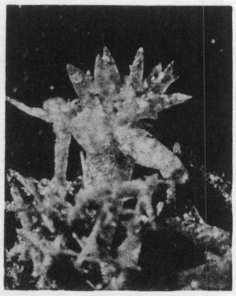

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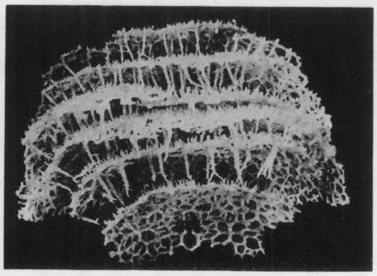

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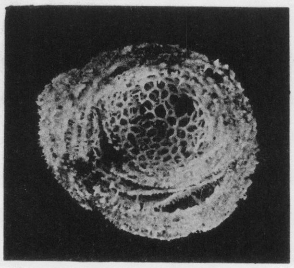

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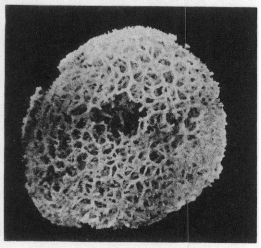

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PLATE 44

1. *Carphites plectus* Finks, new species. Enlarged view of gastral surface of holotype showing large triacts and circular openings of parietal gaps, U.S.N.M. No. 127661, from U.S.N.M. 703c, Word formation.

2–6. *Acanthocoryna stauroma* Finks, new species. 2. Magnified side view of gastral surface showing characteristic gastral spicules in place, holotype, U.S.N.M. No. 127663, from U.S.N.M. 703c, Word formation. 3. Magnified oblique view of dermal surface of same specimen showing characteristic dermal pentacts with distal spines. 4. Magnified view of gastral spicule isolated from same specimen showing ring of spikes on stout, fusiform, proximal ray below crossing and constriction of this ray distal to the ring; distal processes on tangential rays are visible. 5. Magnified oblique view of dermal spicules isolated from same specimen showing smooth tangential rays and rosette of spikes in place of distal ray. 6. Magnified side view of top of dermal spicule from same specimen showing well-developed distal rosette of spikes; some of the stout tangential rays are visible below.

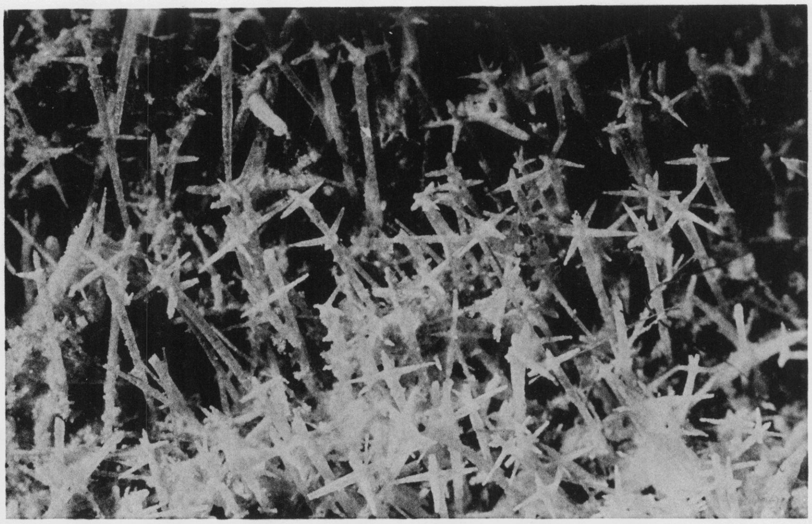
7–9. *Stromatidium typicale* Girty. 7. Magnified view of fragmentary specimen seen in sagittal section, showing layers of fused pentacts; note the fine spinose processes on the distal surfaces of the tangential rays and the spinose, terminally bifurcating proximal rays; at bottom right the four primary tangential rays of a spicule can be seen forming a rectangular cross; A.M.N.H. No. 28080, from A.M.N.H. 403, Bell Canyon formation. 8. Magnified view of another fragmentary specimen viewed from below showing concentric shells, concave side facing the observer; the circular opening at upper right is a cross section of the cloaca, or canal, which leads to the osculum; A.M.N.H. No. 28080:1, from A.M.N.H. 403, Bell Canyon formation. 9. Magnified view of convex top of same specimen showing oscule in center.

1 is twice natural size; 7–9 are five times natural size; 2 and 3 are 10 times natural size; and 4–6 are 15 times natural size.

PLATE 45

Acanthocoryna stauroma Finks, new species. 1. Magnified oblique view of dermal surface of holotype showing area of unusually small dermalia which have weakly developed distal processes, U.S.N.M. No. 127663, from U.S.N.M. 703c, Word formation. 2. Magnified side view of gastral spicule from same specimen accompanied by hexacts. 3. Magnified view of bundle of oxeas from same specimen which make up much of the inner skeleton. 4. Magnified top view of dermal surface of same specimen showing parallel overlapping tangential rays of dermalia of various sizes. 5. Magnified side view of an unusual dermal spicule from same specimen, which bears a ring of stout spikes below the tangential rays as in the gastral spicules; note the very long proximal ray accompanied by smaller oxeas. 6. Magnified top view of dermal surface of same specimen showing dermalia with varying degree of development of distal rosettes; the spicule nearest the bottom shows four horizontal rays in this rosette which bisect the angles between the main tangential rays beneath them.

All are 15 times natural size.



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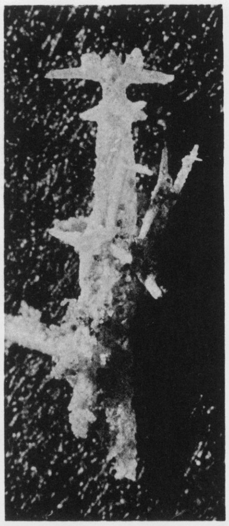

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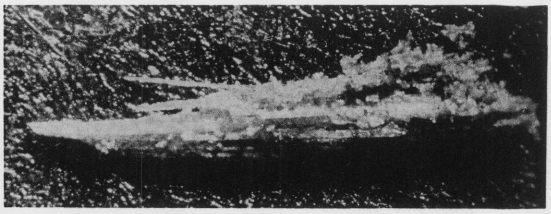

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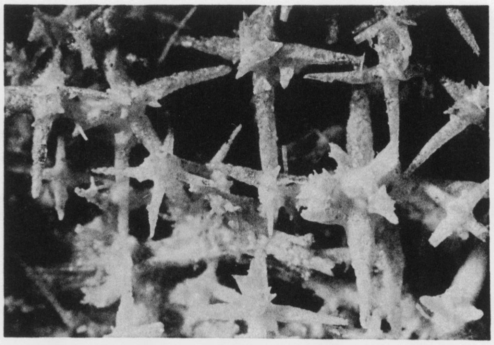

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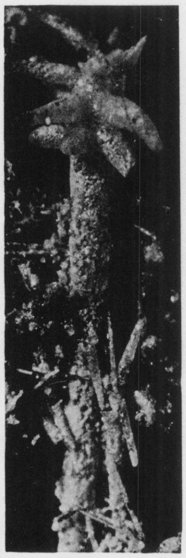

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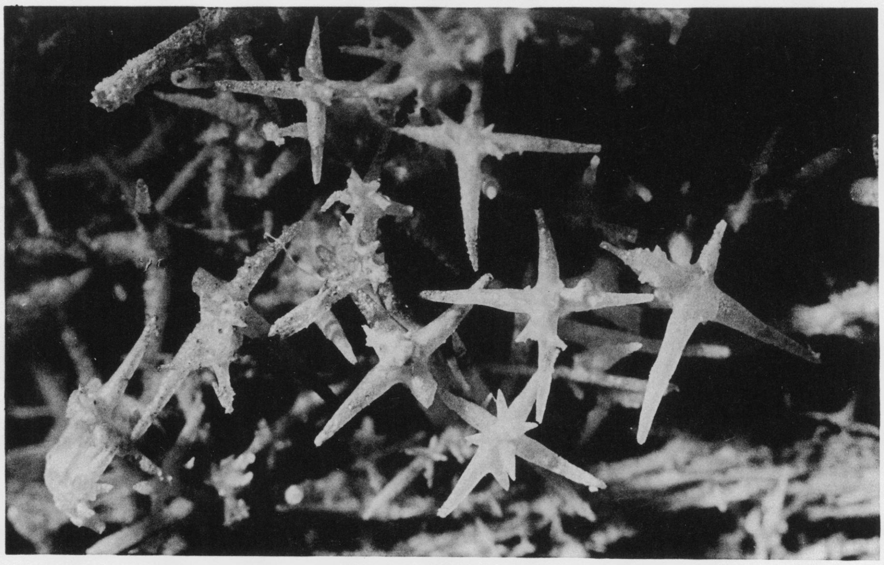

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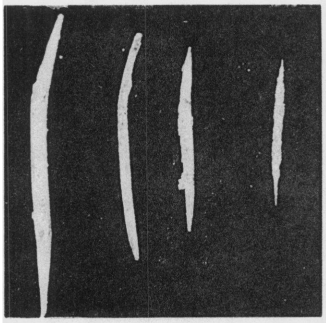
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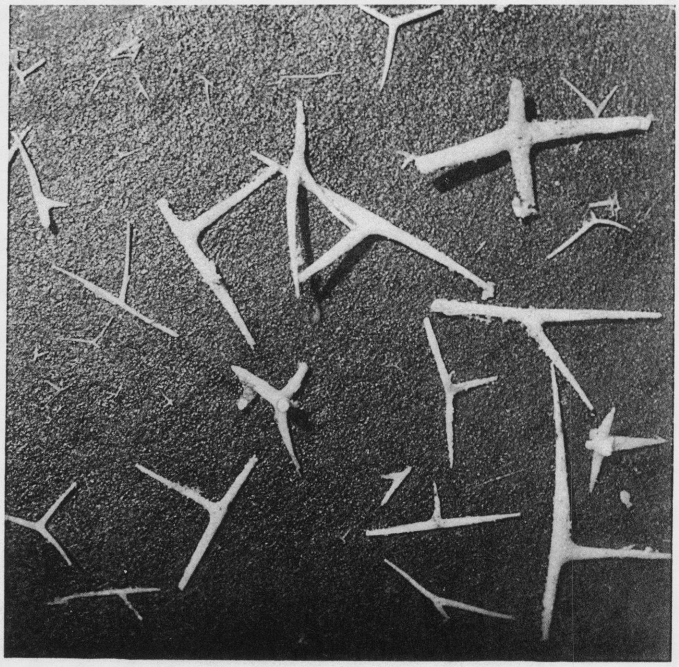
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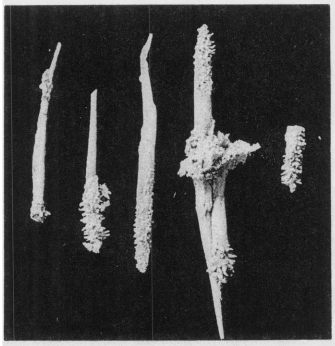
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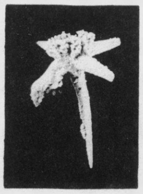
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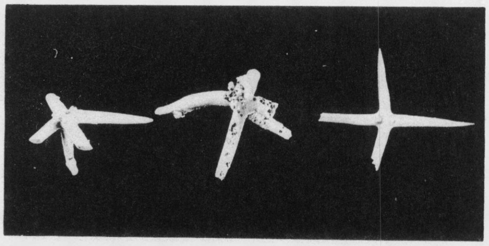
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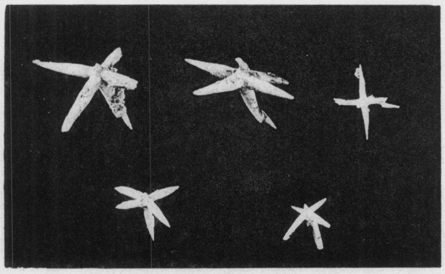
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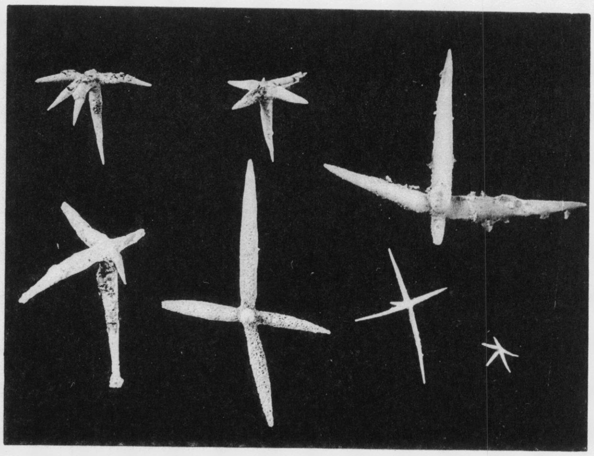
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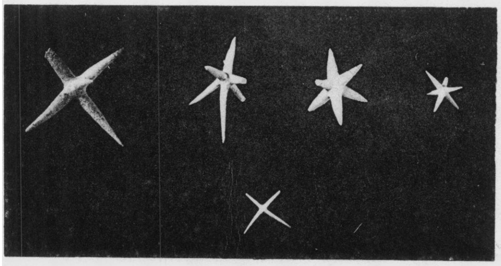
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PLATE 46

1, 2. Large monaxons of uncertain affinities, possibly related to *Acanthocoryna*. 1. Smooth oxeas, U.S.N.M. No. 127664, from U.S.N.M. 703c, Word formation. 2. Oxeas, spinose at one end, presumably the outer end, U.S.N.M. No. 127665, from U.S.N.M. 703c, Word formation.

3. *Carphites plectus* Finks, new species. Magnified view of spicules isolated from holotype, mostly triacts, showing variation in angle between rays; the smaller triacts at upper left are from the dermal layer, the larger from the interior; a large stauract is at upper right; U.S.N.M. No. 127661, from U.S.N.M. 703c, Word formation.

4, 5. Isolated dermal pentacts with distal processes, probably from a species of *Docoderma*. 4. Pentact with reflexed tangential rays and prominent distal spines, A.M.N.H. No. 28081, from A.M.N.H. 503, Word formation. 5. Three pentacts with reflexed tangential rays and small protuberances on the distal surface of each tangential ray near the crossing; the spicule at right shows the distal surface, A.M.N.H. Nos. 28082:1–28082:3, from A.M.N.H. 503, Word formation.

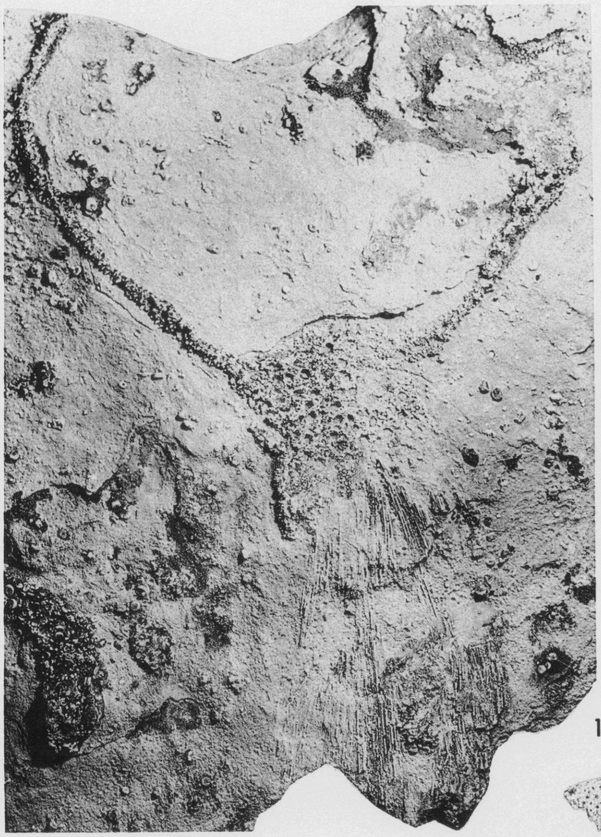
6–8. Isolated spicules, probably dermalia, of *Carphites plectus* Finks, new species. 6. Hexacts with aborted distal ray; some of the rays have been broken and subsequently soldered together; this probably took place during diagenesis; A.M.N.H. Nos. 28083:1–28083:5, from A.M.N.H. 503, Word formation. 7. Regular hexacts in top row showing variation in conicity of rays and in size; at bottom a stauract; A.M.N.H. Nos. 28084:1–28084:4 (hexacts), 28085 (stauract), from A.M.N.H. 503, Word formation. 8. Pentacts of various sizes and shapes; the one at upper left has an extra tangential ray; A.M.N.H. Nos. 28086:1–28086:7, from A.M.N.H. 503, Word formation.

All are natural size, except 3 which is five times natural size.

PLATE 47

Stioderma coscinum Finks, new species. 1. Reduced view of natural sagittal section of holotype on slab of crinoid-bearing limestone, showing general outline of cup-shaped body and root tuft; U.S.N.M. No. 127666, from U.S.G.S. 14444, Victorio Peak limestone. 2. Reduced view of opposite side of same slab showing part of exterior surface of sponge with characteristic pebbly surface and circular parietal gaps. 3. Fragment of gastral surface showing slender oxeas scattered amongst hexacts, paratype, A.M.N.H. No. 28087/2, from A.M.N.H. 512, Getaway limestone member of Cherry Canyon formation. 4. Side view of fragmentary juvenile specimen showing general form of sponge and small size of parietal gaps, paratype, A.M.N.H. No. 28087, from A.M.N.H. 369, Bone Spring limestone. 5. Top view of same specimen showing osculum. 6. Broken side of same specimen showing dermal layer reflexed into cloaca about the oscular margin. 7. Fragment of exterior of specimen showing root tuft (above) emerging from basal edge of dermal layer; note the absence of large parietal gaps; Y.P.M. No. 19593, from Y.P.M. 502, Leonard formation. 8. Interior of same specimen showing root tuft monaxons in interior of sponge. 9. Part of surface shown in 1 showing root tuft of holotype; the interior surface of the lower end of the sponge body is visible at right, U.S.N.M. No. 127666, from U.S.G.S. 14444, Victorio Peak limestone.

All are natural size, except 1 and 2 which are one-half natural size, and 3 which is twice natural size.



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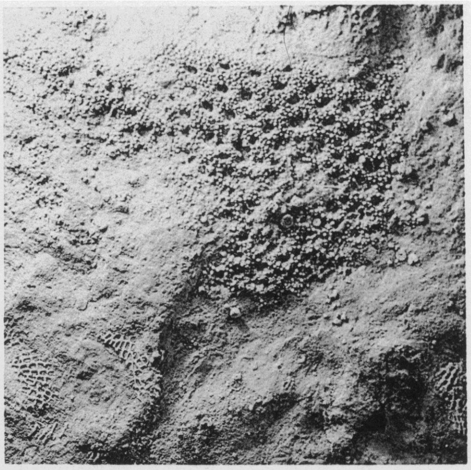

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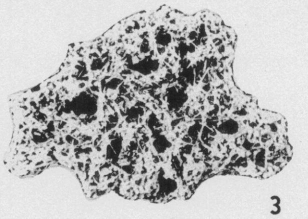

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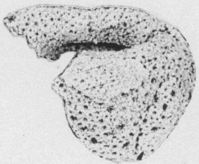

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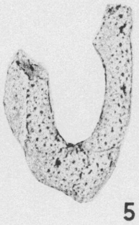

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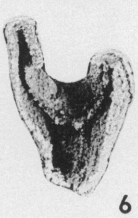

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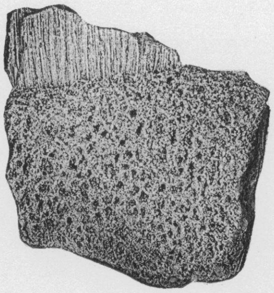

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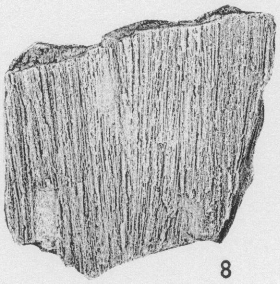

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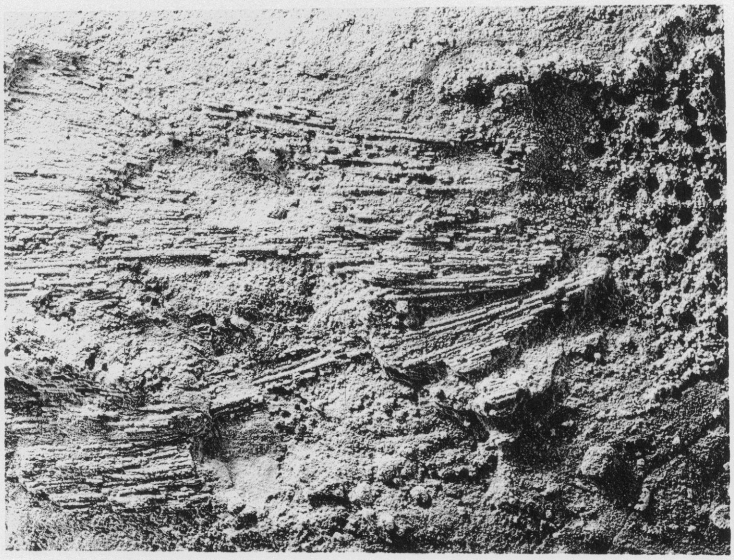

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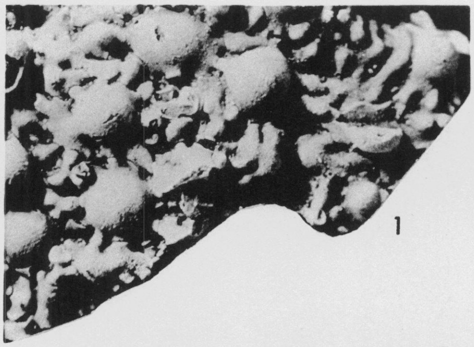
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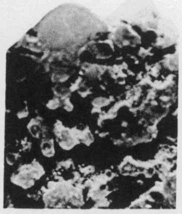
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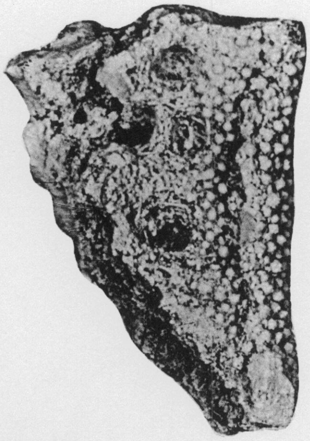
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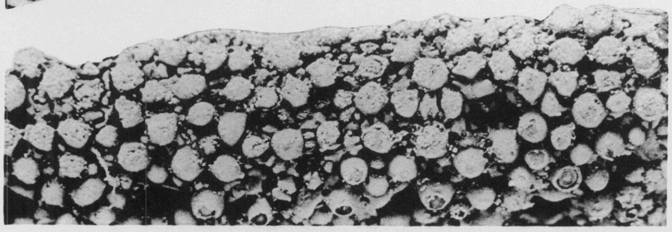
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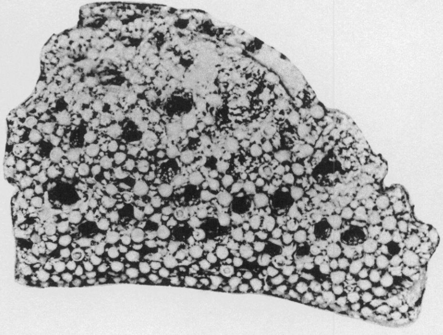
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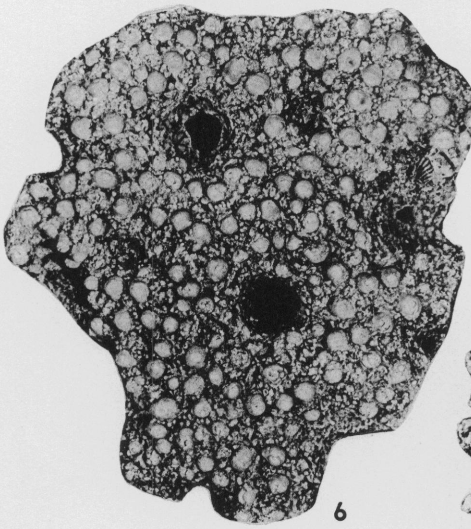
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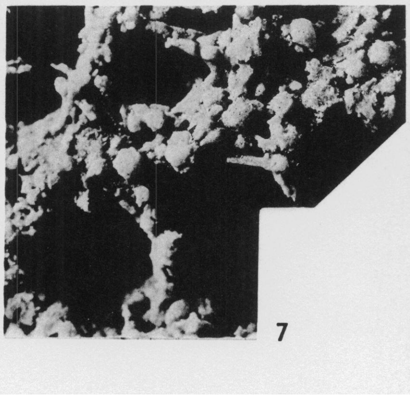
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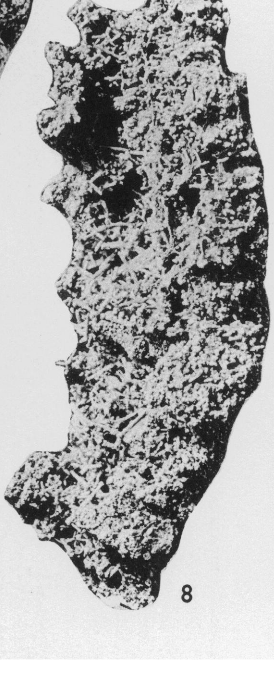
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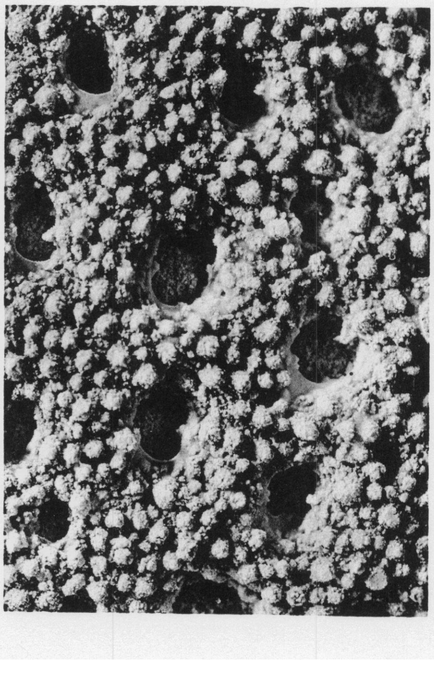
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PLATE 48

Stioderma coscinum Finks, new species. 1. Magnified view of outer surface of specimen with well-developed supradermal mesh connecting the spherical nodes of the large dermalia, paratype, U.S.N.M. No. 127669, from U.S.N.M. 707q, Leonard formation. 2. Magnified view of broken side of same specimen showing, at upper left, a sagittal section through a dermal hexact, with spherical expansion at top, supradermal rays below it, and larger primary tangential rays beneath those. 3. Enlarged view of interior of part of oscular rim (seen at left) showing extension of dermalia, with their spherical nodes, onto the interior surface; in center the inner openings of the parietal gaps are visible; paratype, A.M.N.H. No. 28087/3, from D.W.B. 1144, Cherry Canyon formation. 4. Magnified view of oscular rim of same specimen showing knobs and supradermal net. 5. Enlarged view of outer surface of same specimen showing diminution in size of parietal gaps near oscular rim (bottom). 6. Enlarged view of exterior of fragment with larger than usual knobs and parietal gaps; this may be an ontogenetic difference or possibly a specific one; U.S.N.M. No. 127670, from U.S.N.M. 518a, Millsap Lake formation. 7. Magnified view of exterior showing distortion of tangential rays marginal to parietal gaps, especially visible at middle right, paratype, U.S.N.M. No. 127671b, from U.S.N.M. 702, Leonard formation. 8. Enlarged view of a section through the body wall of another fragment of the same specimen; the exterior is at the right, the cloacal surface viewed somewhat obliquely at the left; U.S.N.M. No. 127671a. 9. Magnified view of outer surface of holotype showing parietal gaps and fine incurrent pores between the distal knobs of the dermalia, U.S.N.M. No. 127666, from U.S.G.S. 14444, Victorio Peak limestone.

3, 5, 6, and 8 are twice natural size; 4, 7, and 9 are five times natural size; and 1 and 2 are 10 times natural size.

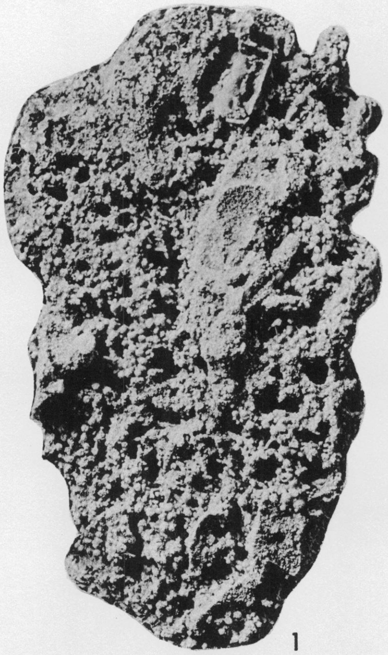
PLATE 49

1, 2. *Stioderma coscinum* Finks, new species. 1. Enlarged view of outer surface of specimen illustrated on plate 48, figure 8; some of the matrix is adherent to the surface; paratype, U.S.N.M. No. 127671a, from U.S.N.M. 702, Leonard formation. 2. Enlarged view of cloacal surface of same specimen showing simple hexacts of the choanosome; note that the openings of the parietal gaps are somewhat larger than the corresponding openings on the exterior; in some cases a dermal spicule may overgrow the external opening, dividing it into two or three smaller spaces.

3–5. *Hyalostelia smithii* (Young and Young, 1876). Type material (syntypes) of the genotypic species from upper part of lower limestone series, lower Carboniferous, Cunningham Baidland, Dalry, Ayrshire, Scotland. 3. Magnified side view of hexact with strongly swollen distal ray (above) and somewhat less enlarged tangential rays, strongly resembling some of the dermalia of *Stioderma coscinum* shown in 6 and 7 of this plate; from Hinde (1888a, pl. 6, fig. 1g). 4. A similar spicule with a more spheroidal distal ray; from Hinde (1888a, pl. 6, fig. 1f). 5. Magnified view of outer surface showing dermalia of a type resembling those of *Carphites plectus* Finks, new species, but smaller; this is the only published illustration of the type material which shows several spicules in organic association; from Hinde (1888a, pl. 6, fig. 1).

6, 7. *Stioderma coscinum* Finks, new species. Magnified views of isolated dermalia, showing variation in size and in degree of development of the distal ray, paratypes, P.U. No. 78903, from P.U. 20i, Bone Spring limestone.

1 and 2 are twice natural size; 6 and 7 are five times natural size; and 3–5 are 10 times natural size.



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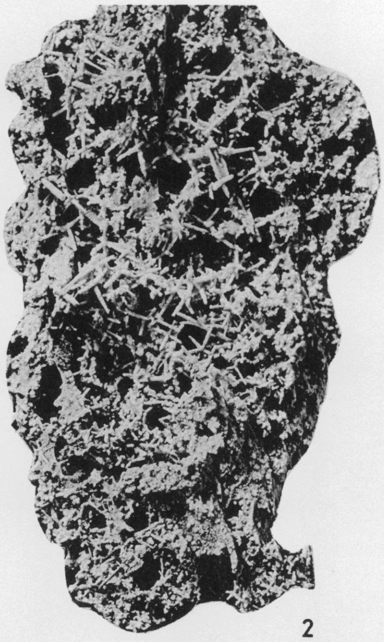

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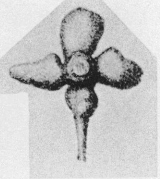

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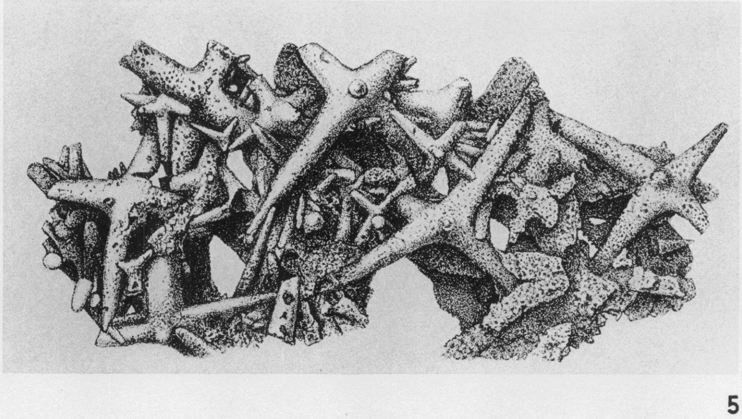

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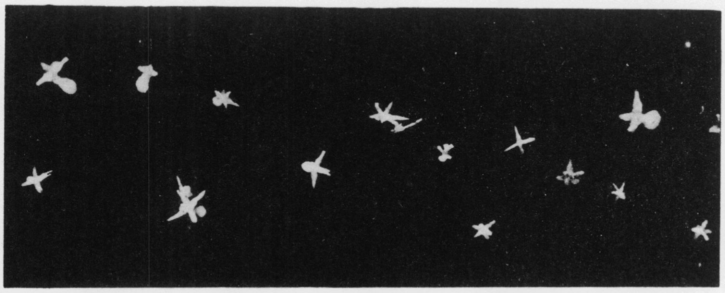

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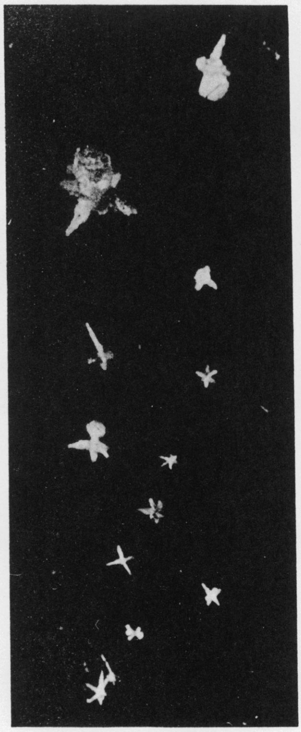

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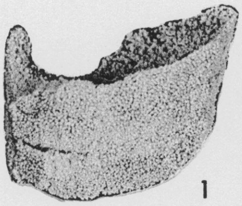

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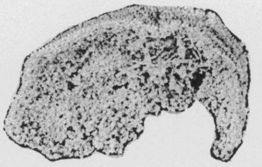

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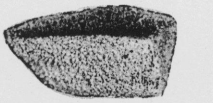

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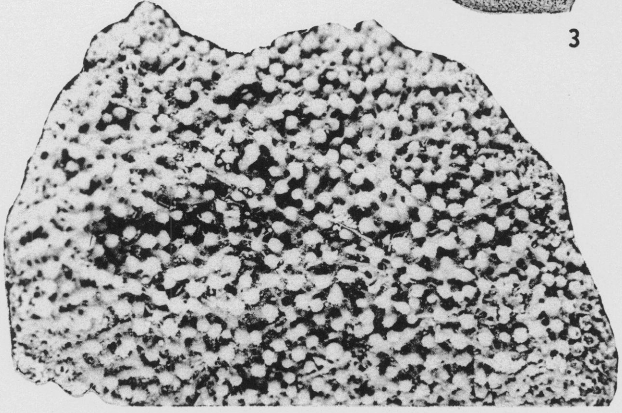

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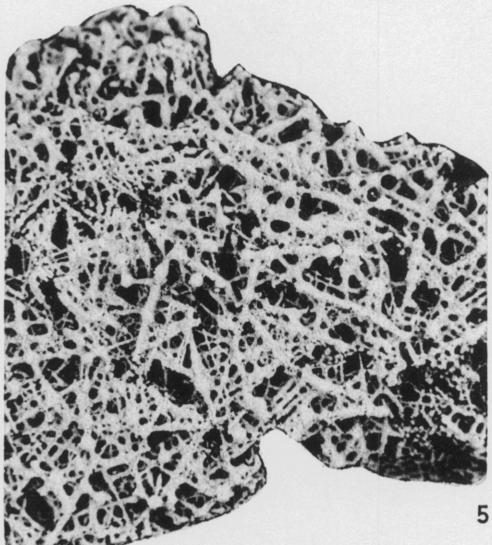

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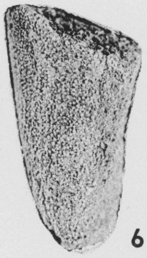

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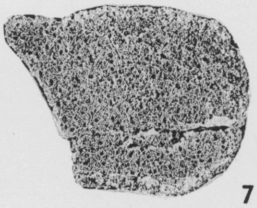

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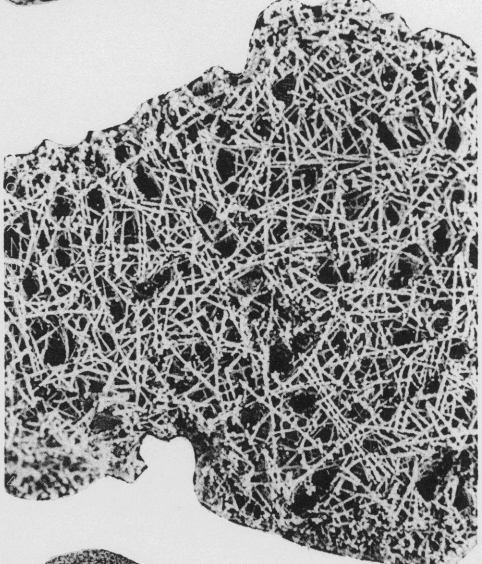

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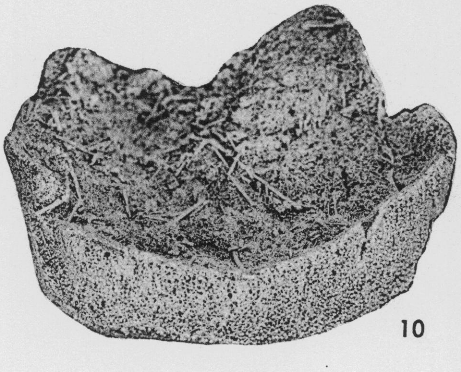

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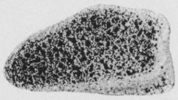

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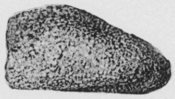

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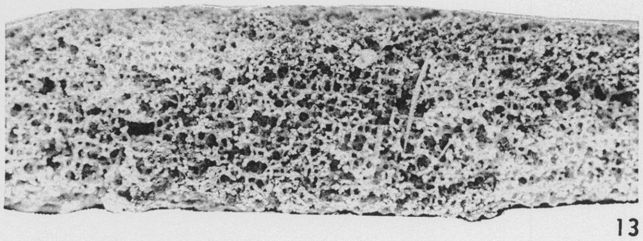

13

PLATE 50

Pileolites baccatus Finks, new species. 1. Enlarged side view of specimen showing growth lines and the characteristic, minutely pebbled surface, paratype, P.U. No. 78863, from P.U. 80c, Bone Spring limestone. 2. Enlarged top view of same specimen showing prismatic outline. 3. Enlarged side view of holotype, a small wedge-shaped individual, U.S.N.M. No. 127667, from U.S.N.M. 707ha, Leonard or Wolfcamp formation. 4. Magnified view of basal (or possibly side) surface of a specimen showing tangential dermalia, each with a well-developed spherical node in place of the distal ray, paratype, U.S.N.M. No. 127668f, from U.S.N.M. 707ha, Leonard or Wolfcamp formation. 5. Magnified view of an unusually open basal surface on which the spherical nodes are not well developed; the random orientation of the long, slender rays is well shown, as is their frequent connection by synapticulae; the tangential rays are heavily thickened by secondary silica, unlike the rays of the upper surface and interior shown in 9; the original ray is sometimes visible in the present figure as a dark line surrounded by a lighter-colored, secondary deposit; paratype, U.S.N.M. No. 127668e, from U.S.N.M. 707ha, Leonard or Wolfcamp formation. 6. Enlarged side view of a tall, wedge-shaped individual, paratype, U.S.N.M. No. 127668b, from U.S.N.M. 707ha, Leonard or Wolfcamp formation. 7. Enlarged view of upper surface of a flat, cake-shaped specimen, broken at the left; the numerous apopores are visible on the surface, as well as the characteristic random pattern of the spicules; paratype, U.S.N.M. No. 127668c, from U.S.N.M. 707ha, Leonard or Wolfcamp formation. 8. Enlarged view of broken side of same specimen showing flatness of sponge. 9. Magnified view of top surface of sponge illustrated in 5, showing long tangential rays of the choanosome spicules united into a continuous net; note the ladder-like configurations of parallel rays connected by synapticulae; the apopores are visible, many of them containing one or more vertical monaxons which appear as white dots; paratype, U.S.N.M. No. 127668e, from U.S.N.M. 707ha, Leonard or Wolfcamp formations. 10. Enlarged view of side and upper surfaces of largest specimen known; the far side is considerably higher than the near one and has a very irregular outline; the specimen seems to be complete and the irregularity natural; paratype, U.S.N.M. No. 127668a, from U.S.N.M. 707ha, Leonard or Wolfcamp formation. 11. Enlarged view of top of holotype showing apopores and prismatic outline, U.S.N.M. No. 127667, from U.S.N.M. 707ha, Leonard or Wolfcamp formations. 12. Enlarged view of base of same specimen. 13. Magnified view of sagittal section of flat sponge similar to that illustrated in 8, showing dense net of horizontal layers of spicules and also characteristic vertical oxeas lodged in the vertical apochetes; paratype, U.S.N.M. No. 127668d, from U.S.N.M. 707ha, Leonard or Wolfcamp formation.

1–3, 6–8, 11, and 12 are twice natural size; 4, 5, 9, 10, and 13 are 10 times natural size.